Printed on Thin Paper for Foreign Circulation.

The Engineer.

Established 1856. Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS & PUBLICATION, 33, NORFOLK ST., STRAND, LONDON, W.C. 2.

Vol. CXXXV.—No. 3514] LONDON: FRIDAY EVENING, MAY 4, 1923 [Price One Shilling By Inland Post 1s. 3d.

PUBLIC NOTICES

Architectural Assistant REQUIRED by the Government of HONG KONG for service as an Engineer in the Architectural Office of the Public Works Department for a period of 3 years, with possible permanency. Salary £460 per annum, rising by annual increments of £30 to £500 and thence (if appointment is made permanent) to £950 per annum. The salary is converted into dollars at the Government rate of exchange, at present fixed at 2s. to the dollar. This rate is open to revision. A conveyance allowance of 240 dollars per annum. Free passages provided. Candidates, unmarried, 25 to 30 years of age, must be architects' duly qualified assistants and belong to the R.I.B.A. Must be conversant with all the usual preparation of sketch designs and working drawings, specifications, quantities, measuring, &c., in connection with new buildings, additions and alterations. They should also have had experience in the design and execution of steel and reinforced concrete structures. Some experience in the maintenance of buildings is also desirable and municipal experience preferred.

Apply at once by letter, stating age, qualifications, and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W. 1, quoting M/11,928. 2380

Power House Engineer REQUIRED by the GOVERNMENT of the GOLD COAST (Takoradi Harbour Works), for one tour of 12 to 18 months' service, with possible extension. Salary £540 a year. Outfit allowance of £45 on first appointment. Free quarters and passages and liberal leave in England on full salary.

Candidates, age 25 to 40, should have had a thorough experience of boilers, steam engines, electric generating plant, switchboard and wiring work, air compressors, rock crushers, pipe work and refrigeration plant for cold storage.—Apply by letter, stating age, whether married or single, and qualifications and experience, to Messrs. STEWART and McDONNELL, 6/7, Cowley-street, Westminster, S.W. 1. 2326

G. R.

Disposal and Liquidation Commission.
PATENTS FOR FIXATION OF NITROGEN.

The Disposal & Liquidation Commission have been instructed by the Treasury to dispose of the Government's interests in certain patents covering new processes for the fixation of nitrogen, based on investigations carried out at the Research Laboratory established during the War under the auspices of the Nitrogen Products Committee. These inventions include more than twenty completed British patents, together with, in many cases, corresponding patents taken out in a number of British possessions and foreign countries for processes comprising the synthesis of ammonia, the preparation and purification of gases, the oxidation of ammonia, and the preparation of nitrates.

The whole rights of the Government in these inventions are now offered for sale, subject to the right of Messrs. Brunner, Mond and Co., Ltd., to non-exclusive licences.

Particulars may be obtained from the Consulting Engineers to the Commission—
MESSRS. J. F. CROWLEY & PARTNERS,
16, Victoria-street,
WESTMINSTER, S.W. 1,
by whom offers will be received for the whole or any of the inventions not later than May 25th.

The Commission reserves to itself the right not to accept the highest or any offer that may be received. 2389 2

City and Guilds (Engineering) COLLEGE, S.W. 7.
ASSISTANT PROFESSORSHIP IN ELECTRICAL ENGINEERING DEPARTMENT.

Owing to the appointment of Dr. Parker Smith to the Chair of Electrical Engineering at the Royal Technical College, Glasgow the Delegacy will proceed shortly to the APPOINTMENT of an ASSISTANT PROFESSOR to deal particularly with the Traction and Design Sections of the Electrical Engineering Department. Candidates for the post will be expected to have had some experience of this work.—Full particulars can be obtained from the SECRETARY to the DELEGACY, The City and Guilds (Engineering) College, S.W. 7. 2370

Administrative County of LONDON.
ABBEY MILLS PUMPING STATION ENLARGEMENT, 1923.

The London County Council invites TENDERS for the CONSTRUCTION of FOUNDATIONS for a new installation of Engines and Pumps, Boiler Foundations and Economiser House, and the CONSTRUCTION of a NEW PUMPING MAIN between the Engine-house and the Northern Outfall Sewers, and other Works in connection therewith, at the Council's Abbey Mills Pumping Station, in the Borough of West Ham, in the County of Essex.

Persons desiring to submit Tenders may obtain the form of Tender, drawings, &c., on application to the Chief Engineer at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £5. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, after 4 p.m. on Monday, 28th May, 1923, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
2376 Clerk of the London County Council.

Bombay, Baroda, and Central INDIA RAILWAY CO.

The Directors are prepared to receive up to Noon on Thursday, 24th May, TENDERS for the SUPPLY of:
1. TYRES for CARRIAGES and WAGONS.
2. WHEELS and AXLES for CARRIAGES and WAGONS.
3. AXLES for CARRIAGES and WAGONS.
4. COPPER FIRE-BOX PLATES.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 20s. each for Nos. 1 and 2 and 10s. each for Nos. 3 and 4 (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tenders.

S. G. S. YOUNG,
Secretary.
Offices: 91, Petty France, Westminster, S.W. 1.
1st May, 1923. 2347

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE.

The Gas Turbine in Theory and Practice.

April Engineering Notes.

The Completion of the Electrification of the Rhaetian Railway.

A Recording Gas Calorimeter.

Fuel Trials at the Lakeside Power Station.

Town Transport.

Milling Machines for Copper Firebox Plates.

Power Station Auxiliaries.

PUBLIC NOTICES

Cardiff Corporation Water-Works.
TAFF FAWR SECTION.
PIPE LINE NO. 2.—CONTRACT NO. 1.

The Cardiff Corporation is prepared to receive TENDERS from competent and experienced persons whose names are on the King's Roll for the CONSTRUCTION, LAYING and COMPLETION of the No. 2 PIPE LINE, 1st Section, and other Works in connection therewith.

The line of pipes will commence near the foot of Cantrell Reservoir (Nant Ddu), Ereconshire, and terminate at Goitre Coed, Quaker's Yard, Glamorgan, a length of approximately 14 miles of 28in. lap-welded steel tubes concrete lined.

Drawings may be seen and printed specification, form of Tender, and bill of quantities may be obtained on application to Mr. C. H. Priestley, M. Inst. C.E., City Hall, Cardiff, after the 2nd day of May next, on payment of a deposit of £20 to the City Treasurer, which will be returned after the receipt of a bona fide Tender with the bill of quantities fully priced out and the specification attached, but on that condition only.

Sealed Tenders, addressed to the Town Clerk, City Hall, Cardiff, and endorsed "Tender for No. 2 Pipe Line, Taff Fawr Section," are to be delivered not later than Twelve Noon on Saturday, the 26th May next.

The Corporation do not bind themselves to accept the lowest or any Tender.

No person should Tender unless he be properly qualified by practical skill and experience acquired as a master contractor in the construction of extensive public works.

Persons proposing to Tender are requested to send in their names at once to the Engineer, giving particulars of contracts carried out by them.

Dated this 23rd day of April, 1923.

CECIL G. BROWN,
2295 Town Clerk.

Corporation of Warrington.
WATERWORKS DEPARTMENT.

The Water Committee is prepared to consider TENDERS for the SUPPLY of a quantity of CAST IRON WATER PIPES of small diameter.

Particulars may be had from the undersigned, and Tenders to be sent in not later than the 12th inst.

JAMES GRAY,
Waterworks Engineer.
Municipal Offices, Warrington,
1st May, 1923. 2360

Madras and Southern Mahratta RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive TENDERS for:

(I.) BROAD GAUGE.
10 UNDERFRAMES for 4-WHEELED LUGGAGE VANS.
50 COVERED GOODS WAGONS, 4-WHEELED.
2 OIL TANK WAGONS, 4-WHEELED.
5 BOGIE OPEN WAGONS.
4 EXPLOSIVES VANS, 4-WHEELED.
7 BOGIE RAIL WAGONS.
6 UNDERFRAMES for 4-WHEELED LUGGAGE and TOOL VANS.
1 OIL TANK WAGON, 4-WHEELED.
5 BOGIE OPEN WAGONS;

(II.) WHEELS and AXLES for the VEHICLES DETAILED ABOVE (in all 446 Pairs of Wheels and Axles),

in accordance with the specifications which may be seen at the offices of the Company. The charge for each specification is One Guinea, which will not be returned.

Tenders must be sent in, addressed to the SECRETARY, not later than 2 p.m. on Tuesday, 22nd May, 1923, and marked "Tender for Luggage Underframes, &c."

The Directors do not bind themselves to accept the lowest or any Tender.

Company's Offices:
25, Buckingham Palace-road,
Westminster, S.W. 1
1st May, 1923. 2378

PUBLIC NOTICES

Redruth Urban District Council.

TENDERS are INVITED for the SUPPLY of ONE TANGYE 25 B.H.P. (Test Load) HORIZONTAL HEAVY OIL ENGINE, Cold Starting Type, with "variable admission" oil governing and automatic ignition by heat of compression.

Complete with usual accessories, driving pulley, compressed air starter, bolts, two water tanks (each 9ft. diameter by 6ft.), exhaust, water circulating, fuel oil and compressed air pipes.

Tenders to state:—
1. Cost of engine delivered at Redruth.
2. Cost of erecting.

Further particulars may be had by arrangement with the undersigned.

Sealed Tenders to reach me by the 15th May, 1923.

My Council do not bind themselves to accept the lowest or any Tender.

T. F. KING,
Surveyor to the Council.
2, Station-hill, Redruth. 2385

Department of Public Works,
Sydney, 31st January, 1923.
SYDNEY HARBOUR BRIDGE TENDERS—
EXTENSION OF TIME.

Tenders are Invited by the Government of New South Wales for the CONSTRUCTION of the SUPERSTRUCTURE and SUBSTRUCTURE of a CANTILEVER BRIDGE across Sydney Harbour from Dawes Point to Milson's Point, embracing a main span of 1600ft. in the clear, centre to centre of main piers, and a length of main bridge 2000ft. centre to centre of anchor piers. The total length of main bridge and approach spans included in Tender is 3610ft.; also an ALTERNATIVE TENDER for the CONSTRUCTION of the SUPERSTRUCTURE and SUBSTRUCTURE of an ARCH BRIDGE across Sydney Harbour from Dawes Point to Milson's Point, embracing a main span of 1650ft. in the clear, centre to centre of bearings. The total length of main bridge and approach spans included in Tender is 5770ft. Either bridge is to provide for four lines of railway, six lines of vehicular traffic, and footway accommodation.

Copies of specification, including plans, technical information, general conditions, and Tender forms, may be obtained by bona fide tenderers on application to the Under-Secretary for Public Works, Sydney, or to the Agent-General for New South Wales, Australia House, The Strand, London; the Minister of Railways and Canals, Ottawa; the Australian Trade Commissioner in the United States, New York; or the Bureau of Foreign and Domestic Commerce, Washington, D.C., United States.

Tenders, the time for which has been extended, must reach the Under-Secretary for Public Works, Sydney, New South Wales, not later than 30th November, 1923.

R. T. BALL,
2035 Minister for Public Works and Railways.

Tyne Improvement Commission.
STEAM TRAVELLING CRANE.

The Tyne Improvement Commissioners are prepared to receive TENDERS for the CONSTRUCTION and DELIVERY at their South Pier Works, South Shields, of ONE 5-TON STEAM TRAVELLING CRANE.

Copies of the form of Tender, conditions of contract and general specification may be obtained from this office on payment of a deposit of £1, which will be returned on receipt of a bona fide Tender.

Tenders, in sealed envelopes, endorsed "Tender for Steam Travelling Crane," must be addressed to the undersigned and delivered to him not later than Noon on Saturday, the 2nd June, 1923.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
RICHARD AUGHTON,
General Manager.
Tyne Improvement Commission Offices,
Newcastle-upon-Tyne,
4th May, 1923. 2368

PUBLIC NOTICES

9/5/23.

State Electricity Commission of VICTORIA, AUSTRALIA.

TENDERS are INVITED for the MANUFACTURE, SUPPLY, DELIVERY, and SUPERINTENDENCE of ERECTION of the following:—
SPECIFICATION 23/63.—ELECTRICALLY OPERATED POWER SHOVEL.

Tender forms, specification, contract conditions, &c., are available upon application to—
Agent-General for Victoria,
Melbourne-place, Strand,
London, E.C.

The charge per one set of two copies of the specification is £1, which will be refunded on receipt of a bona fide Tender and the return of all documents supplied.

Tenders, on prescribed forms, accompanied by a deposit of £50 and endorsed "Specification 23/63.—Electrically Operated Power Shovel," will be received up to Noon on the 31st July, 1923, by
R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
22-32, William-street, Melbourne.

The Commission does not bind itself to accept the lowest or any Tender. 2306

Assistant Engineer-Draughts- MAN REQUIRED for Railway on West Coast of South America. Must be single. Should be able to design track details, such as diamond crossings, switches, &c.; have a knowledge of surveying, design of structures and civil engineering practice. Three years' contract; free passage out and home with £10 expenses each way; free quarters provided. Salary to commence £300 per annum.—Write, with full particulars, to "R. E. B." c/o Charles Barker and Sons, Ltd., 31, Budge-row, Cannon-street, E.C. 4. 2348

Singapore Improvement Trust, SINGAPORE, STRAITS SETTLEMENTS.
SECOND TECHNICAL ASSISTANT.

REQUIRED for service with the Trust, a SECOND TECHNICAL ASSISTANT, age 25-30, unmarried, on a three years' agreement, with possible extension. He must have had a good general education and technical training as a civil engineer. Preference will be given to candidates who have passed the examination and hold the diploma of the Institution of Civil Engineers or of the Institution of Municipal and County Engineers or of the Town Planning Institute. It will be an advantage if candidates possess personal experience as Assistant Engineers in the working of the British Housing and Town Planning Acts (1875, 1890, 1909 and 1919), viz.:—The Improvement of Congested Dwelling Areas, Re-housing, General Housing Schemes, Land Development for Housing, Re-planning and Land Re-distribution Schemes, Suburban Planning, including the usual work for Surveys, Roads, Lay-outs, and General Town-planning.

The salary will be 6000 dollars for the first, 6480 dollars for the second, and 6960 dollars for the third year, paid monthly in dollars (the currency of the Colony), the value of the dollar being two shillings and fourpence sterling. The pay of the appointment for the first year at this rate would be £709. A local transport allowance, subject to variation from time to time as may be sanctioned by the Trust, will be paid. Free first-class passage will be provided, with half-pay during the voyage out. The selected candidate must pass a medical examination.

Applications, stating whether married or single, age, and giving concise dated details of education, training, and experience in general (including war service, if any), with full details of experience in the above class of work, must be accompanied by copies of testimonials and personal references, and be lodged with Messrs. C. C. LINDSAY and PEIRCE, MM. Inst. C.E., 180, Hope-street, Glasgow, Agents to the Trust, not later than Tuesday, 15th May, 1923. 2337

"THE ENGINEER" WANTED.

WANTED, a COPY of "THE ENGINEER" Dated December 26th, 1919.—Address, P5000 The Engineer Office. P5000

SITUATIONS OPEN

WANTED by Well-known Internal Combustion Engine Manufacturers, DESIGNER, capable of developing under the chief line of High-compression Oil Engines (land and marine) from present experimental stage to production stage. Only fully qualified need apply, stating experience and salary.—Address, "COMBUSTION," Wm. Porteous and Co., Advertising Agents, Glasgow. P7330 A

WANTED, ENGINEER for Foreign Sales Department. Well educated, good practical and technical training, also selling experience. French and commercial experience abroad essential.—Apply, giving full particulars of age, experience, and salary required, to HANS RENOLD, Ltd., Burnage Works, Didsbury, Manchester. 2365 A

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SITUATIONS OPEN (continued)

WANTED for London Office, ELECTRICAL and MECHANICAL ENGINEER. Must be a fair draughtsman, with some experience in design. Preference given to one with public works experience. Age 30-35.—Write, stating qualifications, experience, and salary required, to Box 100, c/o Dawson's, 17, Craven-street, Strand, London, W.C. 2. 2370 A

WANTED, INSPECTOR for General Engineering Works; must be experienced in maintaining a high standard of machine shop practice. Applicants state age, experience, and salary.—Address, 2345, The Engineer Office. 2345 A

WANTED, ORGANISER, to Control an Important section of the Sales Department of an Engineering Works. Must be experienced administrator. Knowledge of engineering and publicity work required. —Apply, giving full particulars of age, experience, and salary required, to HANS RENOLD, Ltd., Burnage Works, Didsbury, Manchester. 2368 A

WANTED, Young ENGINEERING JOURNALIST, with previous experience of technical journalism and technical advertising, to undertake whole-time publicity work in connection with electrical, hydraulic, textile, and fire engineering productions.

Apply by letter only in own handwriting, giving full particulars of training, attainments and experience, also salary required, to MATHER and PLATT, Ltd., Park Works, Manchester. 2359 A

WANTED, a YOUNG ENGINEER, with Some knowledge of Oil Fuel and Boiler Economics, to Develop a Flash Boiler at the home of the inventor in Hants, where an experimental boiler has been installed. —Address, 2389, The Engineer Office. 2389 A

A WELL-KNOWN FIRM of ENGINEERS REQUIRE the SERVICES of a REPRESENTATIVE for the Sale of their Manufactures, consisting of Vertical High-speed Steam and Gas Engines, Air Compressors, and Condensing Plants. Applicants must be of good address and have received a sound mechanical and commercial training.—Address, stating age, experience, and salary expected, 2341, The Engineer Office. 2341 A

APPLICATIONS are INVITED for the POST of MECHANICAL ENGINEER and WORKS MANAGER for the large Miscellaneous Engineering Works of a public company near London. Age not to exceed 45, and experience in Electricity and Metallurgy and in the control of staff and works organisation essential. Commencing salary £1000 to £1200, according to experience.—Apply before May 12th, with copies only of testimonials, to Box "G. W. J.," c/o Davies and Co., 95, Bishopsgate, E.C. 2. 2358 A

CAPABLE SALESMEN REQUIRED on Commission basis AT ONCE for the North of England and London district. Must be of good appearance and have a good knowledge of hand-fired furnaces, forced draught.—Address, stating age, experience, and terms required, 2390, The Engineer Office 2390 A

CHIEF INSPECTOR REQUIRED to Take Full Charge of Inspection of Motor Car Parts.—Address, giving full particulars of past experience, salary required, 2394, The Engineer Office. 2394 A

CO_2 RECORDERS.—WANTED, SALES MANAGER, thoroughly competent on the subject, able to take complete control of the sale organisation for the above apparatus. None without the necessary experience need apply. Applicants should send full particulars of their experience and salary required.—Address, P7364, The Engineer Office. P7364 A

FIRST-CLASS ENGINEER REPRESENTATIVE REQUIRED by old-established firm to push sale of Engines, Boilers, Gas Engines, and Plant in West of England and S. Wales.—Address, stating salary required, experience, &c., 2357, The Engineer Office. 2357 A

LIVE REPRESENTATIVE REQUIRED for the Midlands for the sale of high-class Woodworking Machines. Permanent situation. Send fullest particulars, stating age, previous experience (if any), salary and commission required, in confidence.—Address, P7360, The Engineer Office. P7360 A

RATEFIXER, with Wide Experience in Switchgear assembly operations. Only competent and highly trained men possessing substantial experience of this class of work will be considered. Good prospects for suitable man. State age, details of training and experience, and salary required.—Address, 2259 The Engineer Office. 2259 A

REPRESENTATIVE, Technical Experience and First-class Salesman, REQUIRED by a reputed Firm of Furnace Manufacturers. Manufactures meet all modern requirements. Commission basis only to commence with.—Address, P7369, The Engineer Office. P7369 A

WORKS COST ACCOUNTANT REQUIRED, with experience in engineering accounts, in Manchester district.—Address, with full particulars and salary required, 2374, The Engineer Office. 2374 A

WORKS MANAGER WANTED, for General Engineering Works, employing 700/1000 hands; must be thoroughly practical, good organiser and a producer. Knowledge of Patternmaking, Foundry and Machinery essential.—Address, in confidence, giving details of experience, age, qualifications, and salary. 2346, The Engineer Office. 2346 A

WANTED, DRAUGHTSMEN; Must Have Several years' experience of Reinforced Concrete Design. —Apply by letter, stating age, qualifications, and salary required, to the SECRETARY, The British Reinforced Concrete Engineering Co., Ltd., 1, Dickinson-street, Manchester. 2361 A

WANTED, First-class DRAUGHTSMAN, Fully Conversant with Gasworks and Chemical Plants and capable of detailing complete schemes.—Apply, stating experience and salary required, to E. and J. DEMPSTER, Ltd., Gas Plant Works, Oldham-road, Manchester. 2343 A

BRITISH THOMSON-HOUSTON CO., Ltd., Willesden.—DRAUGHTSMEN, with first-class experience of Switchgear Work, WANTED; must be really first-class men.—Write, stating age, experience, and salary required, to CHIEF DRAUGHTSMAN, The British Thomson-Houston Co., Ltd., Willesden, N.W. 10. 2383 A

DRAUGHTSMAN, Experienced Senior, REQUIRED for Steel Railway Carriage and Wagon Work.—State experience, salary required, &c.—Apply, CAMMELL LAIRD and CO., Ltd., Railway Carriage and Wagon Works, Nottingham. 2324 A

DRAUGHTSMAN, Mechanical, Experienced in Jig and tool.—Address, stating age, experience, and salary required, 2362, The Engineer Office. 2362 A

DRAUGHTSMAN REQUIRED for Development and Research Work. Workshop, drawing-office and technical experience essential.—Apply by letter, giving fullest particulars, to ALLEN-LIVERSIDGE, Ltd., Research Department, Manor-street, Clapham, S.W. 4. 2375 A

DRAUGHTSMEN REQUIRED for Switchboard Lay-outs. Good positions for the best type of men.—Address, stating full particulars and salary required, 2384, The Engineer Office. 2384 A

DRAUGHTSMAN REQUIRED by Well-established Works in Midlands. Must be well up in Gasholders and Gasworks Plants. State age, experience, and salary.—Address, 2375, The Engineer Office. 2375 A

DRAUGHTSMAN REQUIRED by London Firm, Refrigerating Engineers. Experience in high-pressure enclosed. Strictest confidence.—Address, P7385, The Engineer Office. P7385 A

SITUATIONS OPEN (continued)

DRAUGHTSMAN, Senior, for Large A.C. Machines and Rotary Converters.—Address, stating age, experience, and salary required, 2314, The Engineer Office. 2314 A

DRAUGHTSMAN WANTED for Ships' Deck Machinery. Only those experienced in Hydraulic Deck Gear need apply. State age, experience, salary required, &c.—Address, 2335, The Engineer Office. 2335 A

ENGINEERS, with London Office, REQUIRE Experienced DETAIL DRAUGHTSMAN for Conveyer and Mechanical Handling Plants; mechanical and structural experience essential. State age, salary, and experience.—Address, 2377, The Engineer Office. 2377 A

MACHINE TOOL DRAUGHTSMAN REQUIRED for Special Tools, Jigs and Fixtures. Applications are only invited from men of first-class ability. Please state experience and salary expected.—Address, 2178, The Engineer Office. 2178 A

WANTED, a Live MAN as MACHINE SHOP FOREMAN, to supervise about one hundred machine tools. Applicants must be familiar with the most modern methods of production and be accustomed to dealing with intricate machine parts as used in printing and lace making or similar machinery. Organiser and executive ability absolutely essential.—Address in confidence, stating qualifications and salary required, 2363, The Engineer Office. 2363 A

FOUNDRY FOREMAN (Working) WANTED, 10 miles out of London, thoroughly experienced.—Send fullest particulars, wages expected, to Box 634, Clark's Advertising Service, 57, Mortimer-street, W. 1. 2333 A

FOUNDRYMEN Wishing to Improve their Position should read Greave's "FOUNDRYMAN'S EDUCATOR," giving mixtures of non-ferrous metals and alloys, irons and foundry productions. Post free 6s.—GREAVES, Harefield Hall, Heywood. P7392 A

SITUATIONS WANTED

ABILITY AND HARD WORK.—SITUATION WANTED where they can make good. Age 37, public school ex-officer, first-class mechanical engineer, electric; late inspector machinery, 1st class British and Govt. India; sound experience works management, competitive construction, control, &c.; trained costs accountancy all office and correspondence; used responsibility and work; thoroughly reliable all branches. Very highest references. Could invest £800/1000 established concern. Brain waves or new patents not wanted, please.—BRAYBROOKE, 29, Darwin-avenue, Buxton. P6902 B

ADVERTISER (24, Single), 4 Years Engineering College, WISHES START, any capacity.—V. E. W., 34, Hart-road, Dorking. P7404 B

CIVIL ENGINEER, Located London, 30 Years' active experience on public works, including 9 in U.S.A., embracing surveys, reports, designs and in charge of construction, DESIRES TECHNICAL APPOINTMENT with financial corporation or would Represent Non-resident Americans having British interests.—Address, P7326, The Engineer Office. P7326 B

CIVIL ENGINEER, University Trained, SEEKS RE-ENGAGEMENT. Sound practical knowledge of all classes of building construction, lay-outs, &c., and well experienced in management of labour; experienced surveyor with good knowledge of D.O. work; also experienced in factory management and running of heavy machinery.—Address, P7397, The Engineer Office. P7397 B

ENGINEER, Age 21, 4½ Years' Pupilage, Good general education, awaiting results of Assoc. Memb. Exam. of I.M.E., SEEKS POST, home or abroad.—Address, P7382, The Engineer Office. P7382 B

ENGINEER and DRAUGHTSMAN (29), First-class workshop and D.O. exp., steam eng., turbines, pumps, plant work, and jig and tool design; 10 years' tech. training; 1st Class C. and G. Mech. Eng. Final, student Bennett's Coll., Strand, Eng. Permanent and progressive SITUATION WANTED in works or D.O. Mod. salary.—Address, P7402, The Engineer Office. P7402 B

ENGINEER (Civil), 30, B.A. (Cantab), Assoc. M. Inst. C.E., SEEKS EMPLOYMENT, with or without investment, commercial or administrative preferred, no selling; willing to go abroad.—Address, P7393, The Engineer Office. P7393 B

ENGINEER, Ex Active Service, Ten Years Loco., machine and erecting shops, Swindon; factory maintenance, pumping plants, overhead structures, &c.; technical and theoretical training, SEEKS POSITION abroad.—Address, P7367, The Engineer Office. P7367 B

ENGINEER, Excellent Long-service Record as Foreman, draughtsman and works manager with general engineers and ironfounders, SEEKS RESPONSIBLE POSITION; well-educated, energetic, successful organiser and controller of labour.—Address, P7266, The Engineer Office. P7266 B

ENGINEER, M.I. Mech. E., will Shortly REQUIRE PERMANENT POSITION; thorough practical and technical knowledge; extensive experience visiting clients, negotiating contracts, attending to correspondence, quotations, and designs, in connection with general engineering, works plant, handling plant, haulage installations, and structural work. Highest references and recommendations.—Address, P7373, The Engineer Office. P7373 B

SITUATIONS WANTED (continued)

ENGINEER (23), G.I. Mech. E., City and Guilds, Finsbury, drawing-office, shops, R.A.F., M.T., REQUIRES POSITION, London, office, works or sales.—Address, P7323, The Engineer Office. P7323 B

ENGINEER (Working) SEEKS SITUATION. Good all-round experience, fitting, turning, charge of plant; 1st Class B.O.T. Certificate.—FRANKIS, 3, Riverdale-road, Twickenham, Middlesex. P7400 B

JOHN HEATH, Cutworth Lodge, Newdigate, Surrey, having 21 years' experience of interchangeable production as chief designer, purchaser and works superintendent, &c., accustomed to control large staffs, OFFERS SERVICES in similar capacity or as London Representative. Inquiries solicited. P7227 B

MECHANICAL ENGINEER (42) DESIRES POSITION. Experience as manager of general engineering business, including pattern shop, foundry, machine shop, smithy, and boiler shop. Used to correspondence, interviews, travelling, and all office routine. —Write No. K817, Keith and Co., Advertising Agents, Edinburgh. P7402 B

MECHANICAL ENGINEER, Degree M.E., DESIRES return ENGAGEMENT for India. Nine years' experience designer and engineer, American steel and allied companies, blast-furnaces, open-hearth furnaces, rolling mills, buildings; three years' recent experience engineer large Indian steel company. Present engagement development engineer prominent firm American engineers.—Reply, J. V. McCartney, 4554, Malden-street, Chicago, Ill., U.S.A. 2271 B

ROLLED STEEL DISC WHEELS for Railway Carriages and Wagons.—ADVERTISER SEEKS POSITION as MANAGER. Has expert knowledge of wheel trade and over 20 years' experience in steel works.—Address, P7387, The Engineer Office. P7387 B

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APRIL.

The Shipbuilding Dispute.

THE unfortunate situation which recently arose in the shipbuilding industry in connection with the question of overtime, night shift and holiday work culminated on the last day of the month in over 10,000 members of the Boilermakers' Society being locked out from the federated shipyards and ship-repairing establishments. After prolonged negotiations, an agreement regulating the conditions of and payment for overtime, night shift and holiday work in shipyards was signed on March 22nd by representatives of the Shipbuilding Employers' Federation and of the Federated Engineering and Shipbuilding Trades. The terms of the agreement were accepted by the men following a ballot vote, the result of which was theoretically binding on all the unions associated with the Federated Trades. Of that organisation, the boilermakers', the plumbers' and the joiners' societies are members, but these three sections instructed their members not to take part in the ballot, and when the result was subsequently announced, refused to be bound by it. Trouble soon arose when an attempt was made to apply the terms of the agreement in connection with some urgent repair work on the North-East Coast, and at the works of Smith's Dock Company, Limited, the boilermakers went on strike in the earlier part of the month. The three unions persisted in their refusal to accept the agreement to which the representatives of the parent body had set their signatures, and as a consequence the federated employers posted notices on the 23rd intimating that work would not be available for members of the three unions on and after the 30th. Subsequent discussion led to a postponement of the notices against the joiners and plumbers for a week, but the boilermakers maintained their stubbornness, with the result that the notices against them took effect on Monday. While the dispute is really one between the parent union and three of its constituents, the employers are vitally concerned in it, in that it involves the whole principle of collective bargaining.

An Economic War.

AFTER occupying the Ruhr for nearly three months the French have succeeded in sending into their country quantities of coke amounting to 4000 to 6000 tons a day from the stocks which had accumulated at the ovens. The total amount available is said to be three-quarters of a million tons, but even while this coke is being cleared out of the Ruhr, the French blast-furnace proprietors are obliged to purchase as much as they can from England and the United States at four times the price they paid for coke before the occupation, and while they complain of these high prices, it is probable that the French are paying still more for the coke which is being procured from the Ruhr at such huge expense. As a matter of fact, the economic war that is being waged between the two countries is scarcely less ruinous than active hostilities, for the aim of each is to do as much injury to the other as possible, and the methods employed are often as ingenious as they are disastrous. It has even been affirmed, though officially denied in France, that the Germans have mixed chemical products with coke to render it unsuitable for use in blast-furnaces. At the same time a large proportion of the ovens have been allowed to cool down and are now more or less deteriorated, so that even should the French succeed in getting men to attend to them, it would still be impossible to produce sufficient supplies of coke. Thus the economic war has so far had no better result than to ruin temporarily the Ruhr coke industry, while the French have not been able to get sufficient out of the district to keep the blast-furnaces going. The effect of this partial economic destruction will be felt for a long while to come. Even should sufficient supplies of coke be forthcoming some time must elapse before the Lorraine furnaces can be put in blast, and a still more serious matter is the necessity of repairing and rebuilding ovens in the Ruhr.

The Football Cup Final Railway Traffic.

IN anticipation of the immense railway traffic expected at Wembley on Saturday last, April 28th, the Metropolitan Railway Company provided at Wembley Park Station, which is on the north side of the British Empire Exhibition grounds, an additional platform, served by two bay lines, which gave six platform roads. The points leading to and from the new roads are operated, at distances of between 350 and 470 yards from the signal-box, electrically by alternating current—the first instance in this country of alternating-current point movement. Between Baker-street Station and Wembley Park, the existing automatic signalling was increased so as to allow for a one and a-half minute's headway between the trains. The London and North-Eastern Railway (Great Central section) enlarged its accommodation at Wembley Hill Station, and, in particular, provided a circular loop on which was a station outside the southern entrance. That company's line between Marylebone Terminus and Wembley was provided with automatic signals so as to allow for a three minutes' service. This installation is of exceptional interest in that it is the first instance in this country of the use of daylight colour light signals on a main line. These light signals are of two types: (1) the Westinghouse and Saxby, as used on the Liverpool Overhead Railway—see THE ENGINEER, November 11th, 1921—and the Hall daylight colour light signal introduced into this country by the General Electric Company. The signalling is also exceptional as regards the overlaps, *i.e.*, the distance beyond the next signal added to allow for the signal accidentally being overrun. Instead of these overlaps being of the 440 yards standard used on steam-worked railways, they are varied between 175 and 650 yards in order to suit the gradients, possible speeds and other conditions. The Great Central work was inspected and passed by Colonel Pringle on behalf of the Ministry of Transport on the 15th of the month.

The Generation of Electricity.

MUCH information concerning the fuel consumption of the generating stations in Great Britain was brought to light in the report issued early in the month by the Electricity Commissioners. While much remains to be done in the way of improving the thermal efficiencies of power plants, there is no question that the colossal waste of fuel that has been going on for many years is steadily diminishing, and that the publication of these reports is causing power station engineers to pay more attention to the fuel economy problem. The thermal efficiencies which are being secured in certain instances would have been deemed quite impracticable fifteen or so years ago, although, of course, even the best stations still leave much to be desired. The highest figure for a large steam station, namely, 17.2 per cent., is, of course, far from ideal, but unless further progress is made in the evolution of generating plant, it cannot be greatly exceeded. Twenty-five per cent. efficiency is, according to Mr. W. M. Selvey, expected from a high-pressure station on the North-East Coast, and if the mercury vapour turbine can be made to work satisfactorily, 30 per cent. might be reached. A small oil engine station showed during the period covered by the report a thermal efficiency of 29.15 per cent. For the generation of electricity on a large scale, however, the steam turbine is the prime mover that is now employed, and in the absence of something better, every endeavour must be made to get the very best results from steam stations.

Commercial Treaties.

THE long and laborious negotiations between France and Belgium for a commercial treaty have been brought to a satisfactory conclusion, and the treaty is now ready for signature. Until the document is published it is impossible to give any idea of the nature of the concessions which have been made on both sides, but it is to be presumed that the new tariff proposals in Belgium have exerted some influence on the treaty, and there are grounds for believing that Belgium has been able to secure certain important advantages. It is stated that one of the clauses gives to Belgian manufacturers the privilege of tendering for contracts in the French colonies. This is being strongly opposed by French manufacturers, who have always been accorded a monopoly of colonial business on the ground that as French capital and energy are employed for colonial development, the supply of material and the carrying out of engineering undertakings should be reserved for the home industry. Seeing that Belgian manufacturers have every advantage over their French competitors in the way of lower production costs, it is feared that they will secure an unduly large share of the work. Moreover, if Belgian firms are allowed to tender for colonial contracts, it will be necessary to accord the same privilege to British and other firms, so that the French will lose their monopoly and will be competing, in many cases, under unsatisfactory conditions. If the privilege said to be offered to Belgian manufacturers is not limited by certain restrictions, it would appear that the French Government is taking a broader view of trade than it is generally credited with, and that foreign firms may be permitted to take part in colonial development.

A Broken Locomotive Crank Axle.

ON the 19th of the month there appeared the report to the Ministry of Transport by Colonel Pringle on the failure on December 4th of the crank axle shaft of 4–6–0 "Claughton" class engine No. 2511, of the London and North-Western Railway. The engine in question was drawing the 10.20 a.m. express from Euston to Liverpool, and when near the 54¼ milepost and ¼ mile south of Castlethorpe Station, whilst running at 60 miles per hour, a heavy lurch and a crash occurred, causing the driver to bring the train to a standstill. It was then found that the tire of the right-hand intermediate driving wheel was missing and that some of the spokes as well as part of the rim of that wheel were broken away. The crank shaft was also found to be broken inside the boss of the right-hand driving wheel, with the result that the wheel was resting on its tire in the "four-foot," and the top leaning against the inside of the engine frame. No other wheels of the train were derailed, and there was little damage to the coaches. The road was, however, badly knocked about. There were no personal injuries, but the fireman suffered from shock effect. Colonel Pringle reports that the mechanical tests, sulphur prints, chemical analysis and microscopical examination of material from the broken axle showed:—(*a*) Marked segregation of sulphur and phosphorus; (*b*) considerable percentage in excess of the works specification of chromium and phosphorus contents in most of the samples, and of carbon in all of the samples analysed; (*c*) great lack of homogeneity in the material; (*d*) overheating during manufacture of the shaft. It was clear, therefore, that the material from which the axle was built was unsuitable for the purpose. In view of the unsatisfactory character of the steel resulting from this particular cast, Colonel Pringle thinks it desirable that all axles made from it should be withdrawn from service. He understands that this is being done. He agrees with the company's technical officers that there is no known practical method of discovering hidden flaws of this character.

Unemployment Insurance.

DURING the month a report on unemployment was issued by the Ministry of Labour. It deals with the administration of Sec. 18 of the Unemployment Insurance Act of 1920, and recounts the steps taken in recent months to examine the possibility of extending unemployment insurance by industries. Feeling that the investigations of these proposals would be assisted by an account of the statutory provision now in force and of the attempt which has been made to give effect to them, the Ministry deals with this matter at some length in Parts 1 and 2 of the present document. In a third part the action taken in recent months with a view to ascertaining the views of industrial organisations, and the possibility of bringing into more extended operation the principle of unemployment insurance by industries is described. The memorandum issued some months ago by the Ministry of Labour is also quoted at length. In an interesting section particulars are given of the only scheme for unemployment insurance by industries that has actually been put into operation. It is noteworthy that this scheme is run by the insurance companies themselves for the insurance of their own employees. On that account it must be regarded as distinctly exceptional, since the insurance industry is in quite a different category from that of constructive industries. The whole report is a very valuable summary of the present position of this extremely difficult subject.

Literary Engineering.

COMPLAINTS are made in France that sufficient attention is not given to the literary training of engineers whose technical attainments, while being of a high order, may not fit them for administrative positions without a certain facility for expressing themselves clearly in communications and reports. It is, of course, assumed that an engineering student has already acquired a sound general knowledge as well as the means of expressing himself grammatically, but a perusal of technical reports shows that, as a rule, he fails to express his opinions and ideas in a way that shall prove convincing to those who may not be able to follow his technical deductions easily. The engineer has often to deal with abstruse subjects for directors, shareholders, financiers and others who require information to be presented to them in a clear, concise and logical manner, and a readable style will be more effective and more helpful to the engineer himself than the stilted phrases that too often figure in tech-

nical reports. An attempt to raise the standard of literary engineering is being made by an association of engineers from the Ecole des Mines, which has instituted prizes to be awarded to students passing out of that school, who are required to submit either a purely literary essay on a general subject or a communication dealing with economical matters. Of the seventy students passing out of the Ecole des Mines this year fifteen competed for the prizes, and four were considered to have presented communications of sufficient literary merit to justify awards.

The Budget.

THE introduction of the Budget by the Chancellor of the Exchequer on April 16th was awaited with much interest by all sections of the community, and it is generally agreed that Mr. Baldwin's proposals, if lacking in originality, are sound economically. A reduction of the income tax by 6d. and an equal reduction of the corporation tax, together with a diminution of postal and telephone charges, are all moves in the right direction. The industrial community would have liked to see the corporation tax abolished altogether, on the ground that it is purely an emergency measure and pressed unduly upon already overtaxed industries, but in view of the general situation and trade depression, a complete abandonment of this irksome tax was scarcely to be expected. On the whole, business men are fairly unanimous that the Chancellor has produced a Budget which goes some way, at any rate, towards lightening the burdens of industry pending the general revival of trade, which will only come about when the European situation is much more favourable than it is at present.

French Laboratories.

THE past month has seen the carrying out of an active campaign in favour of subscriptions for scientific laboratories, which, in France, are often very poorly equipped through lack of funds for their installation and maintenance. The value of scientific research work as a means of aiding industrial development has been so strongly impressed upon the nation that the appeal for funds is being freely responded to by all classes of society. Already more than a million and a quarter francs have been raised, and it is certain that this represents only a small proportion of the total that will be forthcoming when the various manifestations which are being organised produce their contributions to the fund. Sporting and theatrical events are being arranged, and it is hoped that the engineering trades will follow an example already given of working an hour for the laboratories. Chambers of Commerce and other bodies are also making large contributions. This financial effort is regarded as of national importance as a means of enabling France to hold her rank in scientific and industrial progress. In a recent address M. Georges Claude declared that despite what had been done in invention, the field of research had only been covered to a small extent. It is, he says, surprising what is reserved for investigators who adopt scientific methods. In his opinion the field for invention is unlimited.

The Retford Collision.

THE report of Colonel Pringle on the fatal collision of February 13th on the north side of Retford Station was issued on the 26th of the month. In this case, it will be remembered, the East Coast sleeping car express from Aberdeen and Glasgow to King's Cross ran past the signals at two boxes, and, at full speed, came into collision with a goods train which was under the protection of the signals at a third box. The engine was No. 298/Z of the 4–4–2 type, weighing, with its six-wheeled tender, 112½ tons. The train consisted of a twin sleeping car carried on three trucks, one twelve-wheeled ordinary sleeping car, one twelve-wheeled bogie brake, four eight-wheeled bogie vehicles, one six-wheeled and two four-wheeled fish trucks, weighing 272 tons 6 cwt. The engine of the express ploughed its way for 80 yards into the goods train and destroyed the van and sixteen wagons. Its front end, after losing the bogie truck, rode over the accumulated *débris* until eventually the engine overturned and fell on its left side at an angle of 45 deg. across the adjoining up goods line. The report observes that the accident was typical of the class preventable by automatic train control, and the circumstances will, no doubt, receive attention from the Committee appointed by the companies to consider the report of the Automatic Train Control Committee. In the meantime, detonator placers, whereby signalmen can lay detonators on the rail without leaving their boxes, are recommended.

The Completion of the Rhaetian Railway Electrification.

No. I.

THE Rhaetian Railway serves to link up the principal localities of the canton of Grisons, in Eastern Switzerland, with Coire, or Chur, the capital; its ramifications extend to Disentis, in the Upper Rhine Valley; Davos, in the tributary valley of the Landwasser; with extensions to Filisur, on the line to the Engadine, and St. Moritz, Pontresina and Schuls-Tarasp, in the Engadine. The system represents a total length of track of about 280 kiloms. and includes gradients up to 4.5 in 100; the gauge of the lines is 1 m. Originally built for operation by steam, the whole line has now been entirely converted for electric traction, the single-phase system with current at 11,000 volts, 16⅔ cycles being adopted.

POWER SUPPLY.

The first sections to be electrified were the Engadine lines, which have been electrically operated since 1913. The current for these lines is obtained from the Brusio generating station of the Rhaetian Power Supply Company, situated in the Posciavo Valley, whence it is transmitted over the Bernina Pass to the Bevers sub-station, a distance of about 40 kiloms. The latter sub-station is equipped with two 1300 kilovolt-ampère motor generator sets for converting the supply from three-phase at 23,000 volts, 50 cycles, to single-phase at 11,000 volts, 16⅔ cycles.

After the interruption of the war work was again

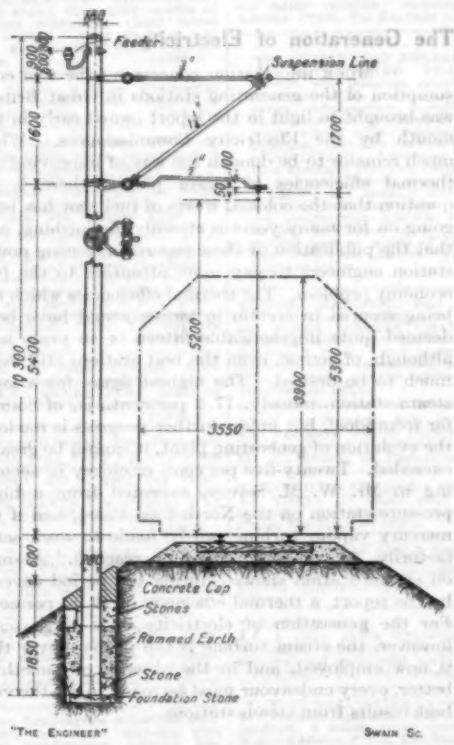


FIG. 1—OVERHEAD CONSTRUCTION ON THE STRAIGHT

resumed in 1918, in which year the electrification of the Bevers-Filisur section was taken in hand, and the conversion to electric traction of the whole network was finally completed in 1922. As the provision of a special power station for the requirements of the various lines was out of the question, owing, principally, to the high cost of building prevailing at the time, it was decided to secure the necessary additional energy from the Küblis generating station of the Grisons Power Supply Company and from the Thusis generating station of the Rhaetian Power Supply Company, which undertaking had, in fact, recently taken over the Brusio generating station with its sub-station at Bevers. The Küblis generating station, a view of which shortly before completion is shown in Fig. 10 on page 474, thus supplies current to the Küblis-Klosters-Davos-Filisur and Küblis-Landquart-Reichenau sections, while the Thusis generating station and the Bevers sub-station feed the Engadine lines and the Bevers-Filisur-Bonaduz and Reichenau-Disentis sections. It will be seen from the map we reproduce in Fig. 3 how favourably these three main feeding points at Küblis, Thusis and Bevers are distributed over the system.

The Thusis generating station is equipped with two hydro-electric sets of 2000 kilovolt-ampères each for the traction supply. The Küblis generating station employs one 2400 kilovolt-ampère hydro-electric set for this purpose; but it will be supplemented, as soon as the three-phase installation of the power station is completed, with a motor generator set of the same capacity consisting of a single-phase generator direct coupled to a three-phase induction motor. This motor generator set will serve, not only for the purpose of supplying current to the single-phase system, but also for feeding back the regenerated energy into the three-phase system. In case there is no train travelling up-hill at the time the energy so recovered will be taken up by opening a hydraulic braking nozzle on the turbine of the hydro-electric set. The current for the traction supply is, in the case of both power stations, generated at the pressure of the overhead line supply, namely, 11,000 volts at a periodicity of 16⅔ cycles.

DISTRIBUTION SYSTEM.

The Küblis and Thusis generating stations and the Bevers sub-station are arranged to work either in parallel or independently. In order to permit of the latter mode of operation, dead sections are provided in the overhead line conductor for isolating adjoining distribution systems. These dead sections are so dimensioned that two locomotives coupled together can pass them without bridging two neighbouring systems. As the dead sections are situated on level portions of the line there is little danger of the trains coming to a standstill at points where they cannot receive current.

The cross section of the line conductor is 85 square millimetres. The feeders are run alongside the track on the same poles as the line conductor, wherever possible. The method of connection adopted for feeding points is shown in Fig. 3, already referred to. The feeder switches at Küblis, Thusis and Bevers, as well as those at Reichenau and Filisur for the lines branching off there, are of the automatic oil-break type; all the other switches on the system are of the horn type. The latter design has proved entirely satisfactory and it possesses, at the same time, the

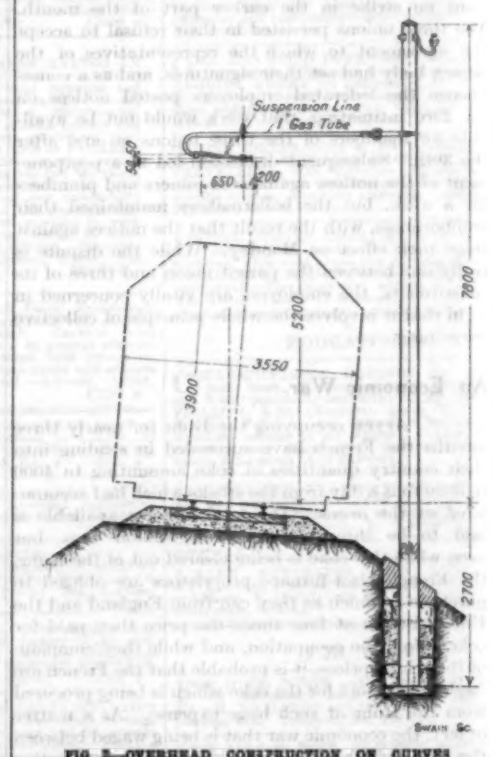


FIG. 2—OVERHEAD CONSTRUCTION ON CURVES

advantage of being cheaper than the oil-immersed type.

OVERHEAD EQUIPMENT.

The overhead line is carried by wooden poles, which it is proposed to replace at a later date by iron posts The foundations were originally made of concrete so as to permit of their use for both wooden and iron poles. This type of foundation has, however, now been abandoned, as in individual cases, where iron posts have been provided, it was found easier to erect the new poles quite independently. Consequently, a cheaper type of foundation, such as shown in Figs. 1 and 2, which is used on the Landquart-Klosters and Reichenau-Disentis sections, has since been adopted. These drawings also show the way in which the overhead line is supported.

The line conductor is hung from a suspension cable made up of seven strands of galvanised steel wire of 2.7 mm. in diameter. This cable is in turn supported directly by insulators, except in the case of the Reichenau-Disentis section, where a lighter system of suspension has been adopted in order to reduce costs. In the latter case the brackets themselves are under pressure and are carried on insulated supports which permit of a certain swing of the brackets about the pole. This mode of suspension is similar to that used on the Riksgräns line of the Swedish State Railways, and has given excellent results. The illustration reproduced in Figs. 11, on page 474, illustrates a sectionising point on the Reichenau-Disentis line, which has a counterweight straining device at the free end of the lines. The spacing adopted between poles is 60 m. on straight sections and 35 m. on curves of 500 m. to 400 m. radius, while in the case of curves with a smaller radius one or two additional pull-off

poles are provided. The brackets and supports of the insulators which were used at the outset were only protected by one coating of paint, but galvanised brackets are now used in order to increase durability and to lower maintenance costs.

The devices for sectionising the line conductor are illustrated in Fig. 5 and Fig. 11 on page 474. The former illustration shows the arrangement adopted for sidings and sheds, while the latter indicates the method used on the open track section between Reichenau and Disentis. The insulators first used on the Engadine lines were of the bobbin and petticoat porcelain type, but considerable trouble was experienced with them owing to their cracking as a result of the different coefficients of expansion of the cement and porcelain. Though this difficulty was later overcome by improved construction, it was decided to adopt in future for the whole system grooved porcelain insulators such as were already in use for the tunnels. These insulators are arranged in groups of three, as shown in Fig. 4. It may be mentioned, however, that the good results which have been obtained with glass insulators, under very severe climatic conditions, have led to the use of glass in place of porcelain insulators on an extensive scale.

Certain points regarding the line conductor, such as the arrangement of the overhead system at locomotive sheds, for instance, deserve mention. Fig. 12, on page 474, shows the mode of suspension adopted over the turntable of the main locomotive sheds at Landquart; though these sheds were originally built for nineteen steam locomotives, only eight tracks have been electrified up till now. The whole overhead system above the turntable is isolated from the rest of conductor system and is fed from a special switch.

Apart from the protective devices installed at the power stations, provision has also been made for protective gear all along the lines, approximately every 7 kiloms. This gear consists of lightning arresters used in conjunction with metallic resistances, or, in certain cases, water resistances. The latter, however, have not proved very satisfactory and require, furthermore, considerable attention. On the Landquart-Klosters and Reichenau-Disentis section oil-immersed metallic resistances have been utilised.

Communication and Signalling Circuits.

All inter-urban communication circuits have been removed to a distance of at least 20 m. from the track in order to comply with the Swiss Federal Regulations, while the telegraph lines themselves have been provided with metallic returns even where they only come in the proximity of the track at either end without running parallel with it all the way.

As regards the communication and signalling circuits for the operation of the railway, the circuits for which used to run alongside the track, they have been removed to a minimum distance of 17 m., and telegraph lines have been provided with metallic returns.

Repair Shop Equipment.

The problem of adapting repair shops, originally intended for steam locomotives, to electric traction requirements, is one that calls for special study wherever railway electrification is resorted to. It may therefore be of interest before describing the locomotives themselves to examine the manner in which this question has been dealt with. In this connection we propose to give a brief description of the equipment of the main repair shops at Landquart, and of the work carried out there when overhauling electric locomotives.

Maintenance of the Mechanical Parts.—As electric locomotives represent a large part of the invested capital, it is important that they should only be out of service for as short a period as possible. Consequently, all operations liable to recur at regular intervals, such as the turning of tires—an operation specially frequent in the case of mountain railway locomotives—should be carried out in the least possible time, so that the locomotives should be out of service for a minimum time. Accordingly provision was made at the Landquart repair sheds for a new crane equipment which is capable of lifting bodily the heaviest locomotives and thus permitting of the rapid removal and replacement of axles, and we understand that for turning up its tires the largest locomotives are only withdrawn from service for a period of ten to twelve working days. For repairs entailing the removal of the jack shaft, inspection pits are required. As regards tools, the general equipment already provided for repairing steam locomotives was found to be entirely sufficient.

Maintenance of the Electrical Equipment.—The work under this heading consists primarily in overhauling motors and, more especially, in cleaning the windings—an operation of special importance, as after a certain period the motor windings get covered with a coating made up of carbon dust, particles of metal from the brakes, and even oil from over-filled or leaky bearings, which in time acts as a conductor and may lead to a breakdown. It has been found necessary in the case of the smaller motors and machines not provided with forced ventilation to treat the windings after runs of from thirty-seven to fifty thousand miles. The cleaning operation is carried out as follows:—The motors, when removed from the locomotive, are first thoroughly blown out with compressed air. The windings are then wiped and subsequently washed with benzine in the trough shown in the illustration Fig. 6. The stator or rotor, as the case may be, is then placed in an oven until the windings are thoroughly dry. An insulation test with double the normal pressure is then carried out in

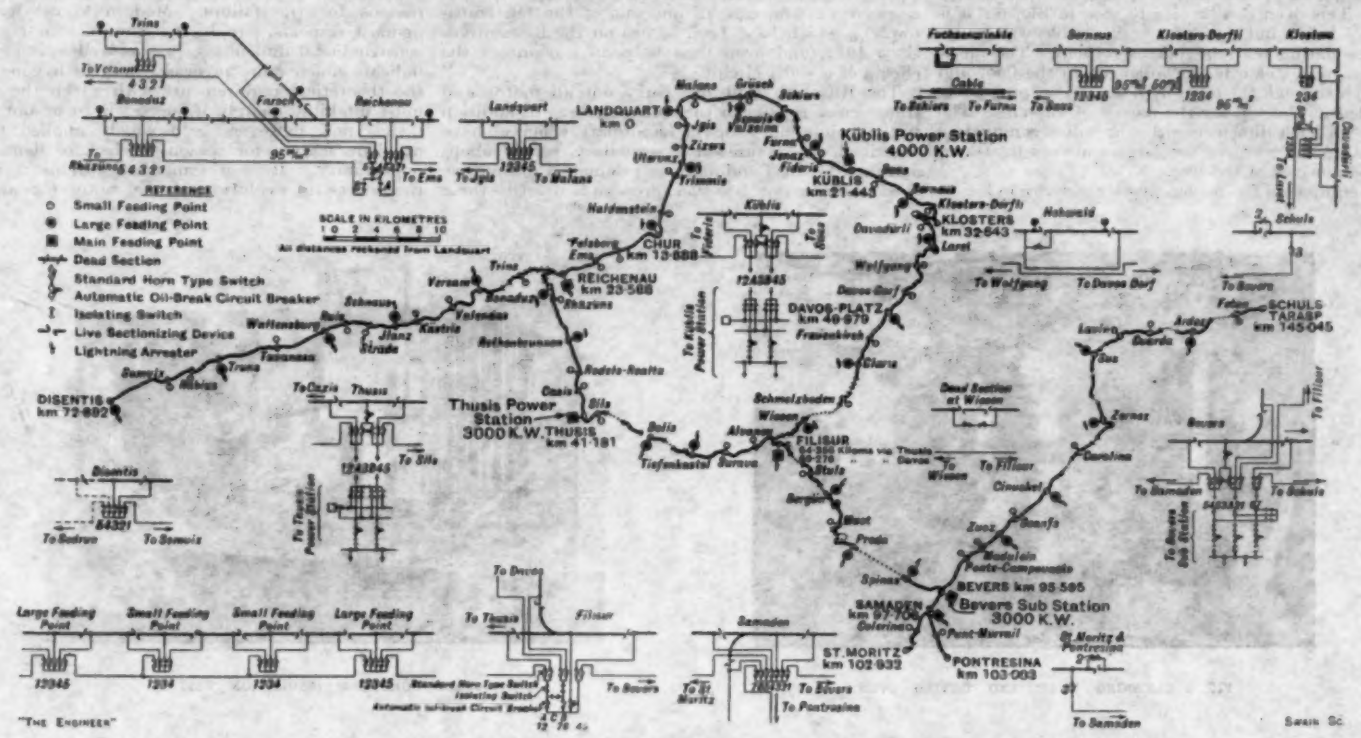


FIG. 3—THE RHAETIAN RAILWAY SYSTEM SHOWING FEEDING POINTS AND DISTRIBUTION ARRANGEMENT

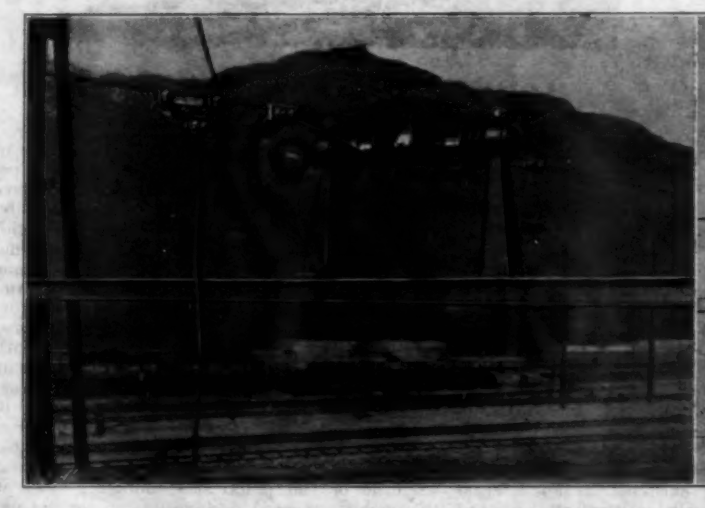


FIG. 4—LINE SUSPENSION WITH GROOVED INSULATORS

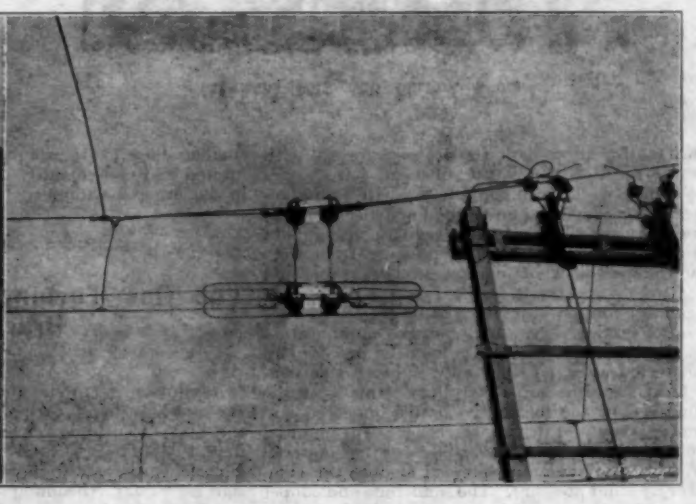


FIG. 5—SECTIONISING DEVICE AT SIDINGS AND SHEDS

order to make certain that there are no weak points in the insulation which require attention. If the winding is found to be perfectly sound, the stator or rotor is then again placed in the drying oven and subjected to a temperature of 100 deg. Cent. The windings are afterwards impregnated by dipping in a bath of insulating varnish and the machine part in question is, after the removal of the varnish adhering to the iron core, replaced in the oven, where the windings are subjected to a temperature of 100 deg. Cent. for eighteen to twenty-four hours, after which a final insulation test is carried out.

It will be observed that the equipment required for the above process includes, first of all, a drying oven. This oven can be clearly seen in Fig. 6; it is built of brick and designed with double walls with heat insulating material between them. The air is warmed by a steam heater arranged in the floor and is driven through the oven by a fan, an opening being provided at the top for the escape of vapours. The oven is of such dimensions that it will accommodate the stator and rotor of the largest motors in use on the locomotives of the line.

The equipment for insulation tests is shown in Fig. 7. It consists of a 20 kilovolt-ampère transformer with a pressure ratio of 380/20,000 volts and a frequency of 16⅔ cycles, working in conjunction with an induction regulator connected on to the low-tension side of the transformer. This induction regulator permits of a variation of the high-tension pressure from 0 to 20,000 volts. The whole equipment is portable and is mounted upon a truck.

The motor commutators have to be re-ground after a period of service, depending upon the commutation of the machine. In the earlier days the process had to be effected after possibly only eighteen thousand miles had been run. For carryingout this work the coupling rod of the locomotive is disconnected and one motor is used for driving the other. The material used for grinding is sandstone, a block of that material being held in a frame and pressed against the commutator by hand pressure. The sandstone and copper dust formed in the process is drawn out of the machine by a fan.

Another important operation which is necessary to carry out from time to time is that of cutting out the mica between the segments of the commutator when the insulating material projects above the metal. This process takes considerable time and necessitates the removal of the armature from the machine. It is therefore usually deferred until the locomotives come to the repair shops for a general overhaul. The machine provided for the purpose consists of an Oerlikon mica cutter, which has apparently given excellent results. It comprises an electrically operated hand miller with a telescopic spindle and a universal coupling at either end—see Fig. 8. With this machine it is possible to cut out the mica on the commutator of a motor armature of a continuous-current locomotive to a depth of .8 mm. in about twenty working hours. As a rule the commutator is turned up before cutting the mica. The lathe for commutator turning and rotor binding is illustrated in Fig. 9.

Mention should also be made of the portable oil filtering plant for dealing with the transformer and lubricating oils. It is driven by a geared pump and has a delivery of about 8 gallons per minute. The transformer oil is strained as soon as its dielectric strength drops below a certain limit; but it is worthy of mention that the treatment of the oil has only been necessary in the case of one out of the ten transformers, which have been in use on the locomotives since 1912, and even then only on account of the effects of a short circuit.

The Rhaetian Railways carry out all motor and transformer repairs in their own shops. In addition to the main repair shops at Landquart, which we have described, there are also secondary repair shops attached to the Landquart and Samaden locomotive sheds. We do not, however, propose to describe these smaller shops, as their equipment is necessarily more limited and consequently of lesser interest than that in the larger shops referred to above.

FIG. 6—CLEANING BATH AND DRYING OVEN

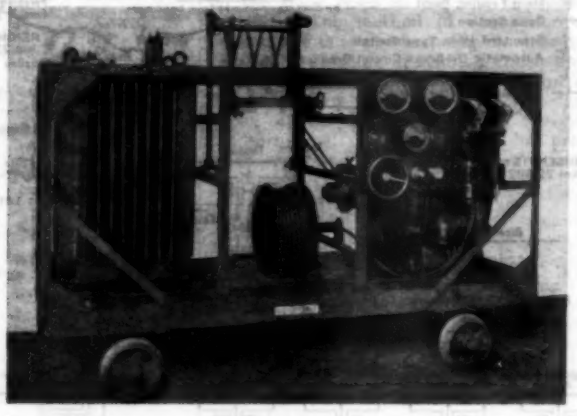


FIG. 7—PORTABLE INSULATION TESTER

FIG. 8—MILLING OUT MICA SEGMENTS

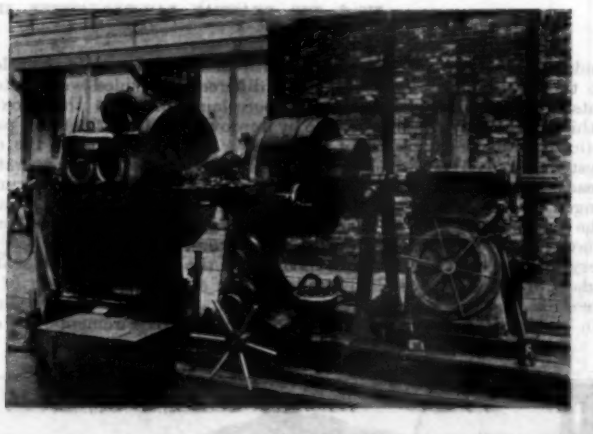


FIG. 9—BINDING AND COMMUTATOR TRUING LATHE

The Gas Turbine in Theory and Practice.

No. I.

ALTHOUGH it is more than twenty-five years since the marine steam turbine was first introduced in the little "Turbinia," and nearly as long since the first 1000-kilowatt land turbine was installed (at Elberfeld), there is to-day comparatively little public sign of the forthcoming existence of an internal combustion turbine of a really satisfactory type, and certainly, as yet, of none which seems destined to exert any such remarkable influence as a power producer which Sir Charles Parsons' invention has exercised either on land or aboard ship. This state of affairs has arisen not altogether from lack of attention to the subject, although it seems somewhat surprising that more has not been accomplished in this country, so much as from the fact that the problem of the internal combustion turbine is an exceptionally difficult one, both as regards mechanical construction and satisfactory theoretical solution. During the last few years, various groups of investigators have been concentrating on the question of evolving a workable and, simultaneously, an efficient design, but progress has been delayed—at least, in Great Britain—probably even more from the fact that the cost of experimental work has risen to such a prohibitive figure during recent times, and that, consequently, all such research has had to be restricted to a minimum, than from any lack of a promising design.

Another reason why wide reluctance towards even the investigation of the subject is displayed is that, justly or unjustly, the gas turbine has been given a bad name, and it certainly sticks to it. Failures to produce a practicable machine have been common in the past, and the broad idea has been largely condemned without any adequate regard for the true reasons for the failure. Modern knowledge can, in most respects, supply the solutions for the early constructional difficulties, just as well as it can now indicate much more precisely than in bygone years the theoretical requirements with which the design must infallibly comply if success is to be obtained; it has not, however, been widely applied to the problem, mainly for reasons of lack of demand or opportunity. It is a somewhat curious fact that the successful evolution of the motor car and the small oil engine had a direct influence on the minds of many engineers, who, during that same period, were also engrossed in watching the early development of the steam turbine. There was undoubtedly created in some circles the extraordinarily optimistic idea that just as the steam turbine threatened at that time to supersede the reciprocating engine in many spheres of application, so the adaptation of the internal combustion cycle to the turbine form of engine would eliminate boiler plants in the manner in which they since have been dispensed with on board ship in cases in which the large slow-running oil engine has been introduced. This view was certainly responsible at the time for a keener desire to investigate the possibilities of the gas turbine than has since been noticeable, and while it cannot be said that these potentialities, either from the scientific or the practical standpoint, were at all thoroughly reviewed or investigated, actual experiment was commoner then than it has been during the last decade. A somewhat curious commentary on the interest which has apparently been displayed over the gas turbine is that, of approximately the two hundred and fifty patents relating to the subject taken out in this country during the last fifty years, practically 40 per cent. were drawn up between the years 1904 and 1906, or during the period when the steam turbine was being so rapidly accepted by the whole engineering world. The truth is that fifteen or twenty years ago, when quite a number of gas turbine experiments were made in various countries, knowledge of turbine or air compressor design, or of the quality of the material to employ for the respective details of construc-

tion, was very lacking compared with what it is to-day; experience of internal combustion, or of the burning of oil fuel, had not attained its present level; designs which offered no possible prospect of success were made and tested, and disappointed their originators; the temperature difficulty and the lack of net turbine efficiency due to indifferent compressors absorbing too much power in negative work, particularly when associated with turbines of very low blading efficiency, and other reasons, all combined to render attempts at solution either abortive or very inefficient. Such results, when contrasted with the satisfactory commercial progress of the steam turbine, the gas engine, the petrol engine, and, later, with the heavy oil engine, led to the early efforts to produce a turbine working on an internal combustion cycle being abandoned as hopeless, whereas they were really only premature or ill-advised.

This attitude still persists, and to-day it would appear that it is now only in Germany that work on the gas turbine is being energetically pressed. Such scant references as are made to the very subject of the internal combustion turbine at meetings of the technical societies in Great Britain are almost universally extremely adverse. Sir George Goodwin, for instance, at a recent meeting of the Institution of Engineers and Shipbuilders in Scotland, stated that he did not think that the oil combustion turbine would make a successful appearance for a good many years to come, while at the meeting of the British Association held last September at Hull, the prospect of the gas turbine coming into being was regarded by several speakers, including such an authority as Professor Gerald Stoney, as virtually impossible commercially without the introduction of some material which could retain at high temperatures the mechanical properties which good high carbon or nickel steel possessed at ordinary temperatures. There is no doubt at all that, for the fullest development of the gas turbine, improvements in design and material are very necessary, but without application to the problem neither are likely to be made, and against these views it can confidently be stated that recent researches in the production of steel alloys and of refractories, together with methods of treatment designed to enable them to withstand much higher temperatures than those generally encountered in ordinary steam practice, have been extremely successful both in this country and in the United States, and that these, coupled with extended studies of designs of internal combustion turbines and improvements actually effected in rotary air compressors, have removed a large number of the stumbling blocks in the way of the early investigators.

The fundamental difficulties in the way of applying the internal combustion cycle, and the use of "gas"—or, rather, of the products of internal combustion—as the working medium in the turbine form of engine, must always remain. The question to-day is not so much one of whether this type of engine can be made to render economical results at all comparable with those obtained from the heavy oil engine—for, at the moment, this is quite impracticable—but whether an internal combustion turbine can be produced which can, in view of the intrinsic advantages of the turbine over the reciprocating form of engine, attain a degree of reliability and efficiency which will afford a novel prime mover a place among those well-tried systems in daily use. Whatever the future may hold in the way of progress, for certain applications it can hardly be doubted that this standard is obtainable to-day, and one, at least, of these applications may prove to be of very far-reaching importance.

With the exception, perhaps, of the Holzwarth constant-volume oil combustion turbine, ordered by the Prussian State Railways, which was, until recently, running at the Thyssen Works at Mulheim, there is probably no practical gas turbine in operation to-day. To assume, therefore, that it is an existing type of engine is, to say the least, distinctly stretching actual facts in its favour. On the other hand, to disparage its possibilities, even with present material and experience, would be very rash in view of the rapidity and extent of development which took place in the case of the steam turbine between one and two decades ago. The *rôle* which the internal combustion turbine could or might fill requires thorough consideration before any attempt should be made to judge of its future, to condemn which, merely on account of past failures, does scant justice to the subsequent growth of knowledge and improvements in material. To regard the as yet undeveloped turbine as a potential competitor of the oil engine, and still more to repudiate its prospects on account of the exceptional economy obtained by the latter, is to take far too narrow a view of the functions which the gas turbine may eventually prove able to undertake without encroaching on existing types for many a year to come. It is undoubtedly with the steam engine (or turbine) *and its boiler and condensing plant* that the gas turbine will prove a formidable competitor, and it has a long road to travel before this really becomes of serious commercial importance. The start may be made any day, even if it may not fairly be considered to have already begun.

Economical as the gas or heavy oil engines undoubtedly are, they are—the latter especially—restricted in power per unit not merely on account of cylinder dimensions limited by the heat stresses in the liner, which are so often quoted as if they were the sole factor concerned, but their design is also very considerably transformed by the revolutions permissible for a given power, which, as with the steam piston engine, result in vast dimensions and weight per unit of power compared with those figures obtainable when, as with direct-connected land or geared marine turbines, an almost unfettered choice of speed of rotation can be made. It is in the obvious advantages conferred by the latter quality that the possibilities of the gas turbine very largely lie, if indeed it is ever to be regarded as a potential competitor in the field of internal combustion. The heavy reciprocating oil engine is very far indeed from being a universal prime mover—its many various types war amongst themselves in a struggle for the evolution of the fittest—and in spite of being able to develop a shaft horse-power with something like double the overall thermal efficiency of the best steam generating station, the proportion of central station power so developed in Great Britain is slightly less than one-half of 1 per cent.! At present its main field lies in certain branches of marine work, the number of which is rapidly extending on account of the well-proved qualities of reliability and economy combined. The real scope for the internal combustion turbine will be found in certain cases where, in competition with steam plants, the elimination of the boiler and condensing installations offer peculiar advantages, while in others, such as the utilisation of blast-furnace gases, the fact that it can be made to develop large powers on comparatively small dimensions may, even in spite of possibly inferior thermal efficiency, render it a suitable alternative to the large gas engine. Until, however, some well-thought-out design is actually constructed and tested, engineers must rest content with estimates of efficiency instead of proofs, and it remains to be seen whether they are of a sufficiently attractive nature to justify embarcation on the development of a new type of prime mover. Without experimental verification, much further progress in the design of the gas turbine cannot possibly be made. It may be of interest, therefore, to review what has already been accomplished in this direction, and, in the light of modern research work directed towards the solution of kindred problems, to indicate how the results obtained in other fields than merely those under discussion have gone far to assist in the eventual development of a turbine working on an internal combustion cycle.

The Early Stages.

When the steam turbine began to supersede the piston engine for purposes of power production, there was no change whatever in either the pressure or the temperature of the working fluid in the new type of prime mover, and because the highest working temperature of steam was not such as to cause any particular difficulty with the usual materials of construction, the fact that in the turbine the admission of heat was constant instead of intermittent as in the piston engine, did not interfere with satisfactory operation. On the other hand, the absence, compared with the piston engine, of all metallic surfaces in contact was eventually found to allow a very considerable increase to be made in the degree of superheat that could be applied, thus incidentally considerably extending the thermal range of the heat cycle at the upper end. But the highest constant pressures and temperatures adopted to-day in steam turbine practice are, after all, only about 250 lb. and 250 deg. Fah. superheat, or a total temperature of about 650 deg. Fah., though in a few special stations boiler pressures of nearly 400 lb. are being adopted in conjunction with maximum steam temperatures of about 750 deg. Fah. at the turbine. If this temperature be admitted to the high-pressure blading of a reaction turbine, it must be remembered that the initial blade speed used at that point is only about 200ft. to 220ft. per second at most, and that the centrifugal stress on the rotor material is therefore very low. If it be admitted through a nozzle on to the first wheel of an impulse turbine running with a peripheral velocity of about 600ft. to 700ft. per second, it must be realised that the total temperature will be reduced by some 150 deg. to 200 deg. Fah. in the passage through the stationary nozzle, and that consequently the wheel will be rotating—but in the first stage only, of course—in a medium of about 600 deg. to 550 deg., a figure hardly sufficient to affect the strength of the material. These figures are below the final temperature due to the single-stage adiabatic compression of air to pressures exceeding ten atmospheres; they are roughly 200 deg. Fah. below the open flash point of heavy oil, and about one-fifth and one-sixth respectively of the maximum temperature of explosion in a Diesel cylinder, or that found in an oil-fired boiler furnace. These latter temperatures exceed that of the melting point of steel, and are only permissible in the former on account of the intermittent nature of their application, coupled with a system of cooling, and in the latter on account of the very rapid transmission of the intense heat into the water on the opposite side of the metal. In the constant-pressure internal combustion turbine, the application of heat at its maximum is constant; both in it and in the constant-volume type the blading is subject to a constant impinging temperature, although one of reduced intensity, but in both cases the function of the material is to withstand the heat and, as far as possible, not to transmit any of it. It will immediately be realised, therefore, what considerable differences and difficulties are involved in the use of internal combustion products, whether expanding in a cylinder against a piston or impinging upon a turbine wheel through a nozzle, for the maximum reduction in initial temperature that can efficiently be used in the latter case is only in the region of 1000 deg. Fah., and therefore the temperatures in furnace, combustion chamber, or explosion chamber, and that on the blading can only be separated by about this amount. This very high initial temperature of the working fluid at first involved very considerable mechanical difficulties, even in the intermittent working of the reciprocating oil engine. It has hitherto almost entirely frustrated the solution of the gas turbine problem, and nearly, if not all, the serious difficulties encountered arise from this one element—the initial temperature. The constructional troubles likely to be created from this cause react on the entire proportions of the design, and in order to obviate them recourse must eventually be had to improving the heat resisting properties of metal. At present it is necessary either to restrict the initial temperature to such a point that, with the nozzle drop, the impinging temperature—probably the cardinal point in all gas turbine design—does not cause deterioration of the blading, or else to accept some form of intermittent working, either of which will reduce the amount of positive work obtainable from the cycle or involve a more elaborate machine. The nature of the internal combustion cycle—to which we shall later refer at length—completes the chain of difficulties, because, if the turbine operates on the constant-pressure cycle, the proportion of negative work to the available positive then becomes unduly large; while if it operates on the constant-volume cycle, the positive work obtainable can only be developed in a multi-chamber machine which, compared with other forms of prime mover, is unduly large and complicated. No; the problem of the internal combustion turbine is not an easy one, but it is far from being an insoluble one, and although hitherto these difficulties have indeed seemingly proved too great, it must be remembered that the subject is one which has been largely neglected for some years. Moreover, the real point at issue must always be borne in mind; there is no question at all of evolving an internal combustion turbine which shall be saliently superior to the present oil engine, just as the steam turbine proved to be to the reciprocating engine; economically this is probably impossible with a non-condensable gas. The real question is whether, in spite of these limitations, and the difficulties which are liable to arise if they are exceeded to any extent, a gas turbine can be produced which will compete with the steam engine and its accessory plant.

So considerable has this temperature difficulty proved in the past, that from the majority of the small experimental gas turbines which have been made during the last thirty years there is absolutely nothing whatever to learn of a positive nature. The writer has troubled to investigate the history of a dozen or so, and has been more or less indirectly associated at various times with perhaps half a dozen others which came into being largely as the success of the steam turbine began to appeal to enthusiasts with elementary knowledge of the petrol engine, but none of the principles of turbine and compressor design. Most of these little machines were far too small and inefficient to prove anything at all, and their accessories were generally far too crude to admit of proper trials being made; little or no provision was made for taking any measurements of performance, and in most cases their very existence is now remembered only by the interested few who recall the episode merely as one involving useless expenditure. In none of these cases, totalling nearly a score, was any published statement ever made regarding even the existence of the machines, and it serves no purpose to recall these efforts were it not for two or three facts that have some bearing on the subsequent history of the gas turbine. Not only has the lack of success left behind an unfavourable impression, but in some cases has definitely proved sufficient to deter originators from re-embarking in after years on similar experimental work in spite of the growth of modern knowledge on the subject. Secondly, the collective experience gained has very clearly demonstrated—if further proof were, indeed, needed—the folly of attempting to obtain in one step too comprehensive a result when so many individual subjects for experiment are at one time involved. In precisely the same way it was afterwards found in experimenting with oil engines, that it was radically wrong to embarass important mechanical experiments with simultaneous attempts, for instance, to burn inferior qualities of coal. Again, a turbine, except for such a unique design as the Laval type, is not a very satisfactory small output machine, even for steam; with gas as the working fluid it is even less so on account of the very much smaller volume per pound, and a great fault in many of these early designs was the fact that the possible shaft horse-power, exclusive of any work of compression, was much too small to admit of any reliable measurements for temperature, consumption, efficiency, &c., being made. A number of isolated experiments on

details connected with the internal combustion turbine problem, which can be conducted at relatively small cost, require to be carried out before a further attempt to produce a complete working installation is made. It is surprising how often, simply for the sake of cheapness and convenience, experimenters have utilised an old Laval steam turbine for absorbing the kinetic energy of their products of internal combustion.

Power Station Auxiliaries.

SEVERAL alternative schemes for the supply of power to the auxiliaries of a proposed new power station are described in a paper on "The Drive of Power-station Auxiliaries," read before the Institution of Electrical Engineers, by Messrs. L. Breach and Midgley, on Thursday, April 26th. The paper covers a considerable amount of ground, although no attempt is made to discuss the relative merits of apparatus, such as evaporators, ejectors, &c., nor have the authors unduly lengthened the paper by including a mass of detail. From the central station engineer's point of view the paper is one of the most useful that has been read before the Institution within recent times. It is obvious, however, that it is very difficult to lay down general rules as to which is the best system to employ for driving auxiliaries, for in many cases alternative schemes are technically equal, and the choice may be based quite well upon the likes and dislikes of the engineer who is responsible for running the station.

For the purpose of considering alternative driving systems, the auxiliaries are grouped according to the length of time during which they may be shut down without causing serious inconvenience and even damage. The auxiliaries are divided into four groups:—(*a*) Those which must not on any account stop, namely, the main circulating water supply, the air extraction equipment and station lighting; (*b*) those which must not stop for more than, say, 60 seconds, including the boiler feed pump and the power for the control circuits; (*c*) those which may stop for up to about five minutes, but not longer, such as water extraction pumps, individual stokers, individual forced-draught and induced-draught fans and ventilating fans; and (*d*) those which may stop for a period of up to about twelve hours without shutting down the station. Among these auxiliaries are coal and ash conveyors, coal crushers, pumps for water-softening plants, and economiser-scraper motors.

The kinds of auxiliary drives considered are:—(*a*) Direct steam drive; (*b*) electric, from main alternators *viâ* high-tension bus-bars; (*c*) electric, from main alternators direct; (*d*) electric, from main alternators *viâ* special windings on main transformers; (*e*) electric, from special steam-driven alternating-current or direct-current generator (house set); and (*f*) electric, from special alternating-current or direct-current generator on shaft of main turbo-alternator. The authors point out that the question of cost should only be considered where absolute reliability has been assured, and in the case of a public supply, if there is any difference in reliability between two alternatives the cost should not affect the decision. For the direct steam drive either turbines or engines may be used. On the whole, direct steam drive requires more attention than electric drive, but it has the advantage of being absolutely independent of any disturbances on the electrical system. For any except very small sizes the engine type need not be considered, for the turbine, either direct coupled or geared, meets the case. Of course, at times of heavy load, if the main steam pressure falls the power and speed of direct steam-driven auxiliaries will fall just when they may be most needed. A considerable amount of attention is required to keep tight the many steam-pipe joints entailed with direct-steam auxiliaries, and the overall thermal efficiency of the station is reduced by the heat losses due to increased radiation surfaces, &c. Further, the use of direct steam drive increases the make-up to almost double, the experience of one American supply company being that the adoption of electrically-driven auxiliaries reduced the make-up of the total boiler feed in circulation from 6 per cent. to 3 per cent.

The one auxiliary for which direct steam drive is especially suitable is the boiler feed pump, the exhaust steam being utilised to heat the feed water, this being particularly convenient when, for any reason, the main feed-heating arrangements are out of action.

When an electric supply for driving auxiliaries is taken from the main alternator *viâ* the high-tension bus-bars this auxiliary supply, if alternating current, may be at the bus-bar voltage or may be reduced by means of transformers, whilst in the case of direct-current the voltage may be whatever is found convenient. Now that the building of alternating-current motors of above about 50 horse-power at voltages higher than 400–500 is a matter of little difficulty, the use of the main generation voltage, or at any rate a voltage of the order of 3000, merits careful consideration. Assuming the main generation voltage to be 6600, this would be too high for any motors except those for the main circulating pumps. A pressure of 3000 volts would be suitable for the main circulating-pump motors, the air-pump and extraction-pump motors—where the latter pumps are both driven by the same motor—and the boiler feed pump motor, but there appears to be little advantage in stepping down to this pressure. In view of the extra cost of the insulation for 3000 volts above the more usual voltage of 400, once it has been decided to step down for the auxiliaries it seems just as well to step right down to 400 volts for all motors rather than introduce another voltage intermediate between that and the main generation voltage.

Direct-current motors require frequent attention to the commutating gear to avoid sparking, and although they are often seen running without any apparent trouble in an atmosphere full of grit and dust, nevertheless the direct-current motor requires more attention than the alternating-current motor. Direct-current machines can be economically subjected to speed regulation over a wide range and, perhaps most important of all, they can be run off a battery in times of breakdown or other emergency.

The greatest disadvantage of alternating-current motors lies in the fact that speed regulation is not an economical proposition. Of course, the speed of a slip-ring motor can be varied over a small range by varying the resistance in the rotor circuit; but this is a very wasteful method, and the system of having a controller to alter the connections of the stator windings so as to alter the number of poles, is only suitable for three or four speeds at the most. Variable-speed motors working on the "cascade" principle might be used, but these give only a limited number of speeds, which are fixed by the number of poles. As final regulation must, therefore, be obtained by the use of valves or dampers, there is no advantage in the installation of this type of motor as compared with the ordinary asynchronous type. In the case of pumps and fans, which form a very large proportion of power station auxiliaries, the output can be reduced by throttling.

It would be interesting to know—the authors remark—whether in actual practice this method of control is any less efficient than the use of variable-speed direct-current motors.

Alternating-current motors, of course, require much less attention than direct-current motors, especially if, in the case of slip-ring motors, brush-lifting gear is fitted. They can run for very long periods without attention, and without having to be stopped for examination.

The practice of taking the supply from the auxiliaries from machine terminals was at one time very popular with one well-known firm of consulting engineers, the main advantage being that in the event of one of the main generator switches being opened the auxiliary supply is not cut off. The practice of taking the electric supply from the main alternator *viâ* special windings on main transformers has been adopted on sets Nos. 3, 4 and 5 at the Dalmarnock station of the Glasgow Corporation. The arrangement is only suitable for a station in which the step-up transformers are directly coupled to their respective turbo-alternators, and the switching is carried out on the high-voltage side. There would appear to be much in favour of this scheme, and it will be of great interest to learn, the authors state, to have the opinion of the Glasgow Corporation after it has been in operation for a year or two. The most popular system of auxiliary electric supply in this country, the authors contend, is that of taking the supply from a special house set; but there is considerable diversity of opinion as to how the exhaust steam should be dealt with. A house set exhausting to its own condenser gives an arrangement which is efficient and self contained but somewhat complicated and, whilst it has many advantages, it entails an increase in the amount of running machinery in the station, a feature to be avoided as far as possible. This scheme may also entail an increase in the station staff. Whether one house turbine is installed for the auxiliaries of each main set—as is adopted for sets Nos. 1 and 2 at Dalmarnock—or whether one house set is installed for the whole station, is largely a matter of opinion. In the case of a station in which for long periods only one main turbo-alternator is on load, one house set per main turbine would possibly be more economical in steam consumption; but, on the other hand, the capital cost of this scheme is much greater than that of the other, and the authors are of the opinion that, where house sets are adopted, it is better to have two per station, one on load and the other for stand-by purposes.

The use of a special generator on the main alternator shaft is a comparatively recent proposal and appears to have much to commend it from the operating point of view, as the supply from it is totally independent of any faults on the main supply, and the only possible source of trouble is internal.

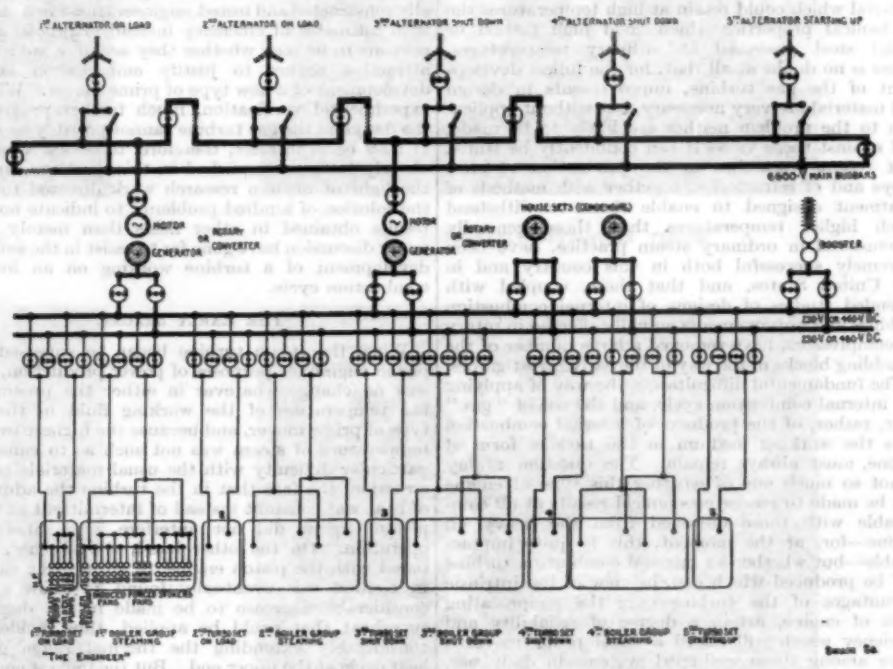
Whether it should be an alternating current or direct current is open to discussion. The excitation of an alternating-current generator is a matter of consideration. It might be excited in parallel with the main alternator, but, in view of the facts that main field rheostats are now practically obsolete, and that voltage regulation is carried out by adjustment of the exciter field, it will be necessary either to have a special field rheostat for this alternator or allow its voltage to vary with the alterations in the exciter field, due to the action of the automatic voltage regulator which is governed by the main bus-bar voltage. As an alternative, the excitation current of the special alternator may be drawn from the battery. This, the authors state, is perhaps the best way.

The paper next deals with considerations appertaining to different combinations of auxiliaries and supplies under various conditions of working, and finally give notes and diagrams regarding individual schemes. In all, seven schemes are dealt with, namely, the use of a special direct-current generator on the shaft of the main turbo-alternator; two auxiliary alternating-current bus-bars, each fed by a transformer; a special alternating-current generator on the shaft of the main turbo-alternator, for turbine auxiliary motors only; a special alternating-current generator on the shaft of the main turbo-alternator for turbine and boiler-house auxiliary motors; a special winding on the main slip-up transformer; and lastly, two direct-current auxiliary bus-bars, fed respectively from a motor generator and condensing house service turbo-alternator. The advantages and disadvantages of these schemes are considered, and the authors point out that it might, in some cases, be advantageous to adopt a combination of them.

One of the schemes, which seemed to be favoured by some who took part in the discussion, and particularly by Mr. J. S. Highfield, is shown in the accompanying illustration, where there are two direct-current auxiliary bus-bars fed respectively from a motor generator and a condensing house service turbo-generator.

The efficiency of this scheme, the authors state, would probably be lower than that which is obtained when all the auxiliary supply is derived from the motive power of the main turbines, but, on the other hand, there are no complications involved in starting up or running.

The spares to be carried would be more than where all the auxiliaries are operated with alternating current, but less than where they are partly worked with alternating current and partly with direct current. Maintenance would probably be high because of the large number of commutator and brush gears. The scheme would be simple to operate and highly reliable, the only drawback being the extra attention required because of the inclusion of a house set.



SCHEME FOR POWER SUPPLY TO STATION AUXILIARIES

The authors are of the opinion that in this case rotary converters instead of motor generators might be installed with advantage, as there is a considerable amount of stand-by plant. It is possible that the reliability might be increased if the auxiliary bus-bars were paralleled by closing the battery on to both bars. By this means the battery would be available as stand-by to both supplies, and the use of reverse-current relays on the direct-current side of the motor generators and on the lead from the house sets would protect both bars in the event of failure or drop of voltage on either supply. An alternative scheme, similar to this, in which alternating-current motors are used throughout, might be put forward, the motor generators being replaced by transformers, the house set being an alternating-current one, and the battery being fed from the auxiliary bus-bars by way of reversible motor-generators.

Such a modification would probably reduce the first cost, but would entail additional complications in running, because of the necessity for synchronising the alternating-current supplies at times of emergency, and also because of the probability of any fault shutting down the motor generators and so rendering the battery of no use at the very time when it is most needed.

A NEW record has been established by a 19.6 Crossley car, fitted with Rapson cord tires and using Wakefield oil, which has recently completed a run of 20,000 miles. This is the first car in the world to complete a road trial of such a long distance under the official observation of the R.A.C. Starting in January, the vehicle covered approximately 300 miles every day—Sundays excepted—until April 20th, when it reached the 20,000 miles. A significant feature of the trial was, it is stated, the consistent trouble-free running of the car and tires throughout the whole 20,000 miles.

A Seven-Day Journal.

The Shipyard Dispute.

WHEN we wrote last week there was some ground for hoping that at the eleventh hour it would be found possible, temporarily at least, to postpone the action of the lock-out notices posted by the federated shipbuilding employers in their yards and establishments on the 23rd. On Wednesday of last week, at the request of the Federated Engineering and Shipbuilding Trades, the employers offered to postpone the operation of the notices for one week provided the members of the three recalcitrant unions—the Boilermakers', Joiners' and Plumbers' —would, in the meanwhile, work under the agreement accepted by the other constituent unions in the parent body, and would resume work in those cases where they had gone on strike. This offer was accepted by the joiners and plumbers, and a notice postponing the operation of the previous lock-out notice for one week—that is, until next Monday, the 7th—was duly issued. The boilermakers, however, persisted in their attitude, with the result that on Monday they were denied admittance to work. The position at the moment of writing is that the joiners and plumbers are at work, observing the terms of the agreement "under protest," while the opinion of the two unions is being determined. The boilermakers, on the other hand, are idle, but a ballot is being taken as to whether the agreement shall be accepted or rejected.

The Late Mr. John Williamson.

ALTHOUGH he was not an engineer, the late "Captain" John Williamson, whose death took place last Friday, played a most important part in connection with the introduction of the marine steam turbine for mercantile vessels. When disaster overtook the turbine-engined destroyers Viper and Cobra, the future of the marine steam turbine was in grave jeopardy. The shipowning companies were not anxious to undertake the risks of pioneering work, and, as Sir Charles Parsons himself has recorded, the fortunes of the Parsons Marine Steam Turbine Company reached a very low ebb. At this stage Captain Williamson approached the Parsons Company and also William Denny and Brothers, with proposals for the construction of a turbine pleasure steamer to run on the Firth of Clyde. The result was that the historic vessel King Edward was launched at Dumbarton in May, 1901. She was very shortly followed by the Queen Alexandra for the same owners, and by a series of cross-Channel and other vessels, culminating in the Mauretania and Lusitania. The King Edward has recently been refitted with new turbines and still, apparently, has many years of usefulness before her. Mr. Williamson was closely associated all his life with the Clyde river steamers and was the author of a most interesting and historically valuable work on the subject which traced the development of the vessels from the time of the Comet onwards. At one time, while he was in control of his own steamers, his brothers, James and Alexander, were responsible for the management of two of the railway companies' fleets.

Electric Locomotives for Mines.

THE Secretary for Mines has announced that Mr. Charles Markham, colliery director, of Ringwood Hall, Chesterfield, has placed at his disposal a sum of £1000 to be offered as a prize for the best type of electrical storage battery locomotive for use in deep and hot coal mines in place of pit ponies. The conditions to govern the competition are now being drawn up by a panel of judges representing the coalmining industry, the Institution of Electrical and Mining Engineers and the Mines Department. The competition will be open to manufacturers of any nationality, but the vehicles selected for trial will be tested in this country. It is expected that a formal announcement regarding the competition will be made shortly. Several types of locomotives of this description are, of course, already being made in this country, but it cannot be said that they are in extensive use in British mines. It would appear that the principal point requiring improvement lies in the batteries.

By Air to Berlin.

ON Monday morning a regular weekly aeroplane service between Croydon and Berlin was begun by the Daimler Airway Company in conjunction with the Royal Dutch Air Service and the Aero-Lloyd, a combination of certain German air lines and the Hamburg-America Company. The machine is timed to leave Croydon every Monday at 9.30 a.m., and flying by way of Amsterdam, Bremen and Hamburg, to reach Berlin at about 6.30 p.m. It is due to return on the following day. A complementary part of the scheme consists of a German service from Berlin to Croydon on Mondays, and the return journey on Tuesdays. This part of the scheme has not yet, however, been begun, owing, it is understood, to some difficulty between the Aero-Lloyd and the German Government over the question of subsidies. It is intended shortly to link up the Croydon-Berlin services with Manchester at one end and Moscow at the other, while hopes are held out that the scheme may develop still farther and ultimately provide a stage in an aeroplane service to India.

New Research Laboratories at Sheffield University.

YESTERDAY (Thursday) Sir Oliver Lodge performed the opening ceremony in connection with two new research laboratories at Sheffield University—the Jonas laboratory for the mechanical testing of materials, and the Edgar Allen laboratory for investigations in connection with magnetism, the magnetic properties of materials and allied subjects. The laboratories are the outcome of two bequests of £5000 made by the late Mr. Joseph Jonas, and by the late Mr. Edgar Allen, and date their conception from the early days of 1914. The Jonas laboratory is equipped with a 50-ton Buckton testing machine, two Armstrong, Whitworth testing machines of 50 and 85 tons capacity, fatigue testing machines of the Haigh, Stromeyer-Gough and modified Wöhler types, Brinell hardness-testing machines, an Izod impact-testing machine, apparatus for determining slip in metals under stress and for measuring the accuracy of standard gauges, and other appliances. The equipment of the Edgar Allen laboratory has been carried out by Dr. T. F. Wall. It includes means for obtaining supplies of direct and alternating current of widely varying characteristics, a very powerful electro-magnet capable of excitation up to 60,000 ampère-turns, a series of vacuum thermo-junctions for measuring very low values of alternating current pressure, a Carey Foster bridge for determining very small condenser capacities and inductances, various standards of capacity and resistance, and a considerable amount of other apparatus.

A Large Canadian Hydro-Electric Scheme.

A FEW weeks ago we referred to the large hydro-electric scheme which Armstrong, Whitworth are now engaged upon at Dear Lake, Newfoundland, under which an initial 100,000 horse-power is to be developed for use in the manufacture of wood pulp and paper. Some details have now been received regarding the still larger plant which the Shawinigan Water and Power Company, of Montreal, is about to erect at Gres Falls, on the St. Maurice River. At this station a total of 120,000 horse-power will be generated for transmission to Montreal. The turbines will be four in number, of 30,000 horse-power each, and will, it is claimed, be the largest propeller-type water turbines in the world. They will work under a normal head of 60ft., and will run at 130 revolutions per minute. Construction work on the dam and foundations has already been begun, and it is hoped to have the entire plant finished by June of next year. When it is completed the Shawinigan Company, from its three stations on the St. Maurice River—at Shawinigan, Gres Falls and Laurentide—will have command of over half a million horse-power. In this instance the hydraulic plant will be made in Canada by the Dominion Engineering Works, Limited, of Montreal, under licence from the William Cramp and Sons Ship and Engine Building Company. The electrical equipment will be supplied by the Westinghouse Company.

Railway and Tube Competition.

A PRIVATE Bill Committee of the House of Commons has been considering a Bill under which powers are sought for the extension of the City and South London Tube Railway from Clapham Common to Morden, a little to the south of Wimbledon, where it would link up with the proposed Wimbledon and Sutton Railway, for the construction of which the Underground Railway received powers in 1910. The Bill has been very actively opposed by the Southern Railway on the ground that the proposed extension would constitute an invasion of the territory of that railway's South-Western Section. Giving evidence before the Committee on Monday, Sir Herbert Walker characterised as "absolute nonsense" the suggestion that the large railways operating within the London area were not concerned with suburban traffic, and stated that his company had spent, and was spending, enormous sums on the development of its suburban lines, a total of between seven and eight millions being within sight of expenditure on electrification alone. He feared that if the extension were constructed it would lead to rate cutting over a very wide area, and a consequent compensating increase of ates elsewhere. It is said that this occasion is the first on which a Parliamentary Committee has had to deal with a question of competition between two railway groups since the Act of 1921 was passed, an Act of which the elimination of unremunerative competition was one of the primary objects. It will therefore be noted with interest by many that on Wednesday the Committee decided that the preamble to the Bill should, in the public interest and as a matter of public policy, be approved.

A Works Migration.

WE learn that within the next two or three months all the activities of the St. Helens Cable and Rubber Company, Limited, at Warrington, will cease, and the entire manufacturing business of the firm be transferred to a new factory at Slough. The new establishment is that built towards the end of the war for mechanical transport repairs, and is stated to be excellently adapted for the company's business. It is to be equipped partly with new machinery and partly with plant transferred from Warrington. The reason for the transference lies in the company's desire to extend its works, and the fact that the site at Warrington did not permit of any extension. Efforts to find a larger factory in the neighbourhood of Warrington failed, but at Slough the company discovered a practically unused establishment with excellent railway facilities, and a site extending to some 200,000 square feet. It is expected that the majority of the firm's staff and workpeople will follow it to its new establishment. Special arrangements with regard to housing and allowances to the company's present servants are being made.

Stainless Steel American Patents.

IN the Journal for May 5th we recorded the fact that in an action brought by the American Stainless Steel Company against the Ludlum Steel Company for infringement of Mr. Harry Brearley's American patents for stainless steel, judgment was pronounced in favour of the Ludlum Company on the ground that its mixture or formula was different from that used in making stainless steel in accordance with the Brearley patents. An appeal was duly lodged against that judgment, with the result that the United States Circuit Court of Appeals has now reversed the former decree, it being held that the Ludlum Company's product is within the disclosure made in the Brearley patents. The Court's judgment is set forth in a lengthy document now before us, and is of the greatest interest to a wide circle, including both metallurgists and those connected with the operation and administration of the Patents Acts. We hope to deal with the subject more fully in a subsequent issue. It may here, perhaps, be mentioned that a peculiar combination of circumstances prevented Mr. Brearley from obtaining a British patent for stainless steel, but that the disability in question did not apply under the American patent law, nor under the laws of about twenty other countries in which patents were duly obtained.

Sixty Years Ago.

PROMINENT in our issue of May 1st, 1863, was an account of the Charing Cross Railway Bridge then on the eve of completion. Many unkind remarks have within recent years been made as to the æsthetic appearance of this bridge, and the benefit that would be derived by pulling it down and removing the station which it serves to the south side of the river. It is interesting, therefore, to note that even before it was brought into use voices were raised against its ugliness. While inclined to defend the design of the bridge on the score that ornament in engineering works was only permissible if it served some useful purpose, we admitted that the time had arrived when iron structures should be made something more than scientific, that a sense of beauty should be united with stern, dogged principles of strength. What judgment in this respect would we have passed, we wonder, could we have foreseen the development of the cantilever bridge, a form of structure in which the principles of strength are expressed with peculiar sternness and doggedness, yet one which to many is not unbeautiful? Such a form of bridge was unknown in those days. "Bridges," we find it written, "must be one of three kinds, either suspension, compression arches, or beams"—the Charing Cross Bridge being of the latter variety. Inventors of spring-tired wheels for railway rolling stock—and they still provide a steady source of income to the Patent Office—will be interested to learn that in a note headed "Elasticity between Wheel and Rail," we gave comparative results obtained from two engines on the St. Helen's railway, one fitted with Krupp's steel tires and the other with Staffordshire iron tires set upon springs in accordance with a system invented by Mr. W. Bridges Adams. After running 41,000 miles the Krupp tires had to be re-turned. The Adams tires after 55,000 miles were still serviceable. Why, then, are spring tires not in general use to-day? We leave the answer to those inventors who are still labouring in this field.

A Recording Gas Calorimeter.

As a result of the Parliamentary decision that ordinary illuminating gas should be sold according to its thermal value, instead of the old system of charging for the volume supplied, there has naturally developed a demand for an apparatus which will measure and record the calorific value, or number therms, of gas.

The problem of devising an apparatus for this purpose, which, obviously, is no simple one, has been attacked by Professor C. Vernon Boys, one of the official Gas Referees, in a characteristically ingenious manner, and his efforts have produced an apparatus which has been sufficiently perfected to have been the subject of a Discourse that the inventor gave before the Royal Institution on Friday, the 27th ult.

At the lecture Professor Boys showed, in the lecture theatre, a calorimeter made in his own workshop, while another apparatus made to his own designs in the Kingsway workshops of John J. Griffin and Sons, Limited, was shown in the library. The only difference between the two examples is that the former has been built up by degrees, and piece by piece, by the inventor in the course of three years of experiment, while the latter has been produced as a commercial article. It is the apparatus by Griffin that is shown in our half-tone engraving.

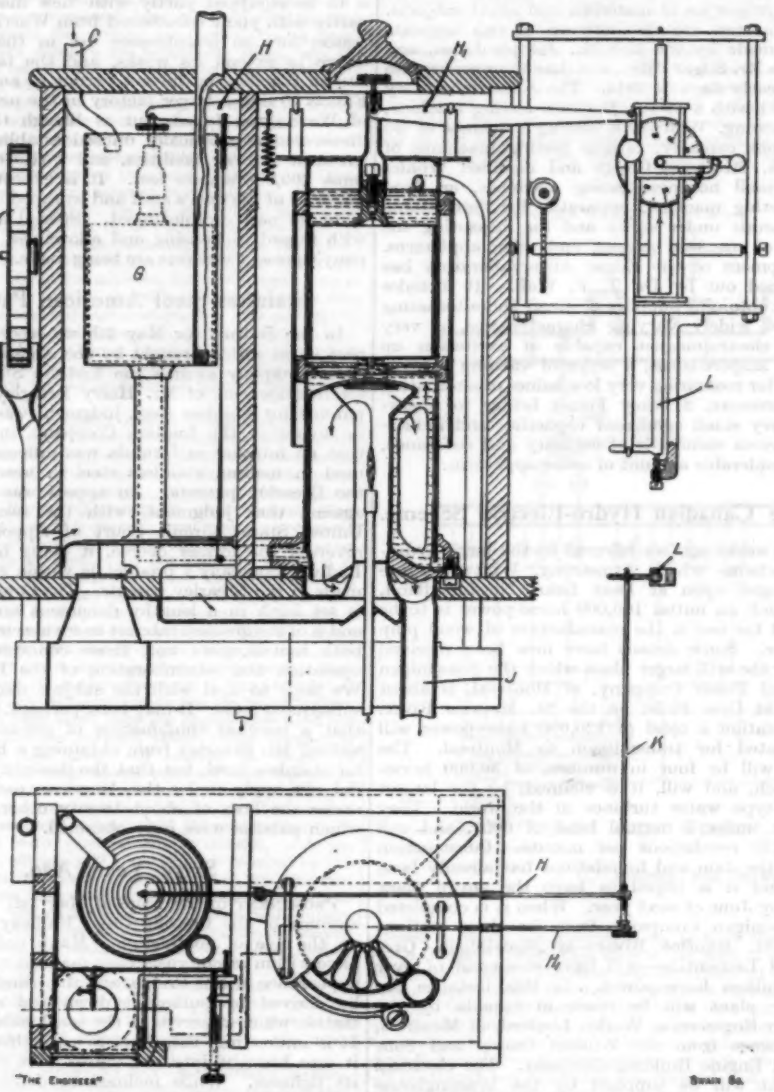


FIG. 1—HEAT-INTERCHANGER, THERMOMETER AND INTEGRATING GEAR

The problem which Professor Boys set himself to solve was the production of an apparatus which would not only measure and continuously record the calorific value of the gas, but also one which might be put under the charge of an ordinary gas inspector, which would maintain its accuracy over long periods of time and which, while having all its working parts disclosed to view, would give a direct indication of being out of order.

The principle on which the apparatus works is the increase in the temperature of a steadily flowing stream of water caused by the consumption of a measured quantity of the gas under observation. It is obvious that the accuracy of the records made by the calorimeter depends on the exactitude with which the water and the gas are measured, and it is noteworthy that a variation of 1 per cent. in the quality of the gas supplied throughout Great Britain has a money value of roughly £500,000. So Professor Boys has gone to very great pains to perfect these two fundamental parts of the calorimeter.

In order to minimise the incrustation of the wetted parts of the apparatus the inventor prefers to use the same water over and over again, but otherwise the two tanks which are shown in Fig. 2 at the extreme top and bottom are not essential. The water in the top cistern is replenished when necessary to make up for loss by evaporation. After it has served its purpose in the calorimeter it passes through the little radiator at the bottom and thence into the lower tank. A small hot-air engine drives a fan to produce a draught through the radiator and also operates a pump for returning the water to the cistern above. The proportions of this part of the apparatus are such that water at room temperature is always available at the upper level.

The supply of water to the calorimeter is brought down by a tube to the jet marked A in the engraving, Fig. 2, and issues as a horizontal jet, towards the back of the apparatus, into a tipping measuring bucket. This bucket, of celluloid, best shown in the sketch, Fig. 3, is mounted on trunnions, which roll on their supports, and its position is determined by the adjustable stop B. When the bucket is full it tips forward, as shown by the dotted lines, and discharges its contents into the chamber below. This chamber is divided into two sections by a partition pierced by a comparatively small hole, with the object of softening out the fluctuations caused by the intermittent discharge of the bucket by the time the water arrives at the outlet C. In the tipped position the bucket is caught by the pawl D engaging with the stop E and is held in this position until it has thoroughly drained.

While the bucket is in this position its side wall does not intercept the horizontal jet from the nozzle A, and the water jumps clear of the chamber below into a separate receptacle at the back. This water, which does not, of course, affect the measured quantity, is led to a little overshot celluloid water-wheel F, that provides the motive power for driving the recording apparatus. The wheel is constrained to revolve once in half a minute by a single wheel escapement and pendulum. Once in every revolution a tappet on the water-wheel lifts the pawl D and allows the bucket to resume its normal position. Thus, it will be seen, the bucket discharges an exactly measured quantity of water exactly at half-minute intervals.

The next step is to take the temperature of the measured water, which is effected in the vessel G, Fig. 1. In this vessel there is the cold-water thermometer, that takes the form of a piece of brass tube about 3in. long by 2⅞in. diameter, with corrugated end plates and filled with amyl-alcohol. The expansion and contraction of this liquid is a measure of the temperature of the water, and is indicated by movements of the lever H. The water flows down round the cold thermometer, and leaving by the bottom of the vessel passes over to the hot side of the apparatus. In this compartment there are the interchanger, through which the heat of the burning gas is transferred to the water, and the thermometer for taking the resultant temperature. The two thermometers are similar.

The heat interchanger is arranged directly below the hot thermometer, and is made of thin sheet lead, as that metal has been found to be most resistant to the corrosive action of the products of combustion. A sectional plan of the interchanger looks somewhat like a single daisy, with the edges of the petals defined by the sheet lead. The radial spaces represented by the petals provide passage for the products combustion, while the intervening crevices and the circumferential space between the interchanger and the nickel-silver tube that forms the case of the water jacket are filled with water. In the centre there is the opening for the flame. Just above the flame there is a small disc of silica, against which the hot gases from the flame impinge. It was found necessary to insert this disc as pimples of incrustation

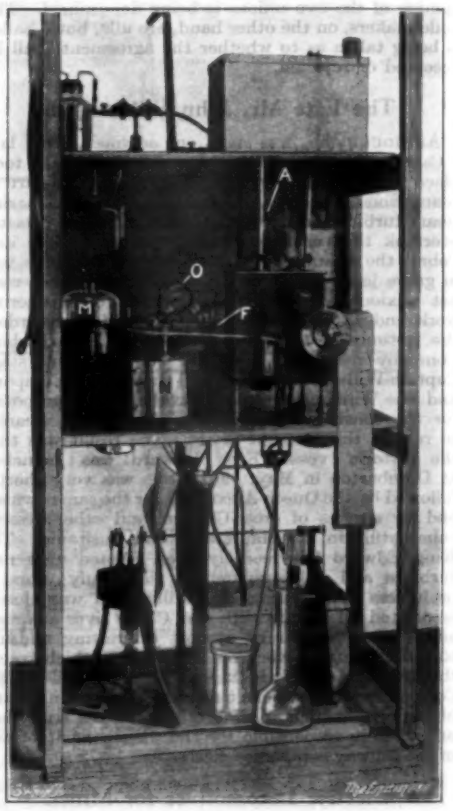


FIG. 2—THE BOYS GAS CALORIMETER

formed on the lead dome of the interchanger when it was exposed directly to the flame, and there was a liability for drops of water—the water of combustion of the gas—to drip from these pimples and put out the flame. On the other hand, the silica disc gets so hot that no condensation can take place upon it, and it is incorrodible. The gas jet, also, is a plain tube of silica.

The gaseous products of combustion flow downwards through the passages in the interchanger and escape by the flue J, while the water of combustion is drained away separately to a beaker on the floor. The measured water coming from the cold thermometer flows upwards through the heat interchanger and after passing round the hot thermometer goes to the tank at the base of the apparatus.

It will be appreciated that all that is required of the thermometers is that they should indicate the rise in the temperature of the water which has been heated by the gas flame, and the system of levers with which they are connected is devised to effect this purpose only. It will be noticed that the cold thermometer is arranged to push up against its lever H, while the hot thermometer pulls down its lever H_1. The two levers have the same degree of magnification—1 to 2½—and their outer ends are in the same plane transversely to their length. On their ends is hung the vertical link shown in Fig. 4. The lower end of this link is connected by the rod K, with a crank arm on the vertical spindle L, Fig. 1, of the recording gear.

The three forces acting on the vertical link keep

it in equilibrium, while relative movements of the two levers H, H_1, will rock it in a vertical plane and thus, through the rod K, will rotate the spindle L. Nevertheless, should both the levers H, H_1 move together in the same direction the spindle L will not be appreciably affected, as the result will be merely a vertical displacement of the hanging link.

At the top of the spindle L there is a long pen arm, made of a piece of capilliary silver tube that records the movements of the spindle on the band of paper seen, in Fig. 1, hanging on the right of the apparatus. The paper is driven by a drum which is geared down from the shaft of the escapement-controlled water-wheel. The paper is not ruled originally, but a row of pens, set at the proper distance apart, continuously marks the necessary divisions, while at fixed intervals of time these pens

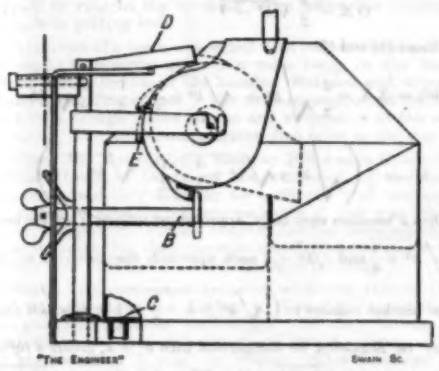


FIG. 3—THE WATER MEASURER

are given a slight sideways jerk to mark every half-hour. Thus it is immaterial whether the paper runs true over the drum or not, as the graduations and records are always made simultaneously. In conjunction with the spindle of the pen arm there is an integrating device, working on the same principle as the Amsler planimeter, and shown in the upper right-hand corner of Fig. 1, that totalises the movements of the pen in any given time. The water-wheel also drives a simple clock movement which has a face in a prominent position at the front of the instrument.

So far we have only dealt with that part of the apparatus which might be described as the water side. The other section, which handles the gas and measures it out, is, naturally, equally important and displays the same ingenuity in its design.

The gas is first passed through regulators to control its pressure, and is then led to a bottle, seen on the top shelf in Fig. 2, which contains wet blotting paper with the object of ensuring that the gas is saturated with water vapour, and thus will not rob the wet meter of its sealing water. A manometer is arranged between the bottle and the meter M, Fig. 2, to indicate the gas pressure.

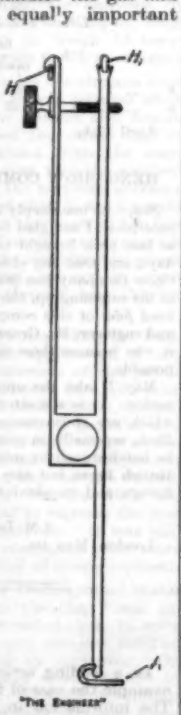


FIG. 4

The meter comprises a celluloid drum, with four measuring compartments, which is partly immersed in water. The water level comes above the drum axle and also above the joint between the casing and the glass dome, so that there is no chance of escape for the gas. The joint where the axle emerges from the casing is sealed with vaseline. The buoyancy of the drum is such that the spindle carries practically no weight and merely serves to locate the drum. The compartments in which the gas is measured are so formed that the sides, ends, roof and about two-thirds of the floor are defined and independent of the water level, while only a small part of the floor is formed by water surface. Thus, even if the water level did change, it would have little effect on the volume of the chambers, but, as a matter of fact, the level does not change.

As the gas has to be delivered to the burner under standard conditions the speed of the meter has to be corrected for atmospheric changes, and this is effected by moving the drum endways along the spindle, so as to open or close the gas inlet orifice. The drum is not keyed on the spindle, but is mounted on a screw thread, and the spindle is rotated by the clock-controlled water-wheel. If the drum and the spindle turn at the same rate there is no endways movement, but a change in the speed of the spindle will push the drum one way or the other, and thus regulate the gas inlet. Hence, if a mechanism is introduced to modify the clock speed, at the meter spindle, in accordance with the atmospheric conditions, the necessary regulation is obtained.

The speed-regulating gear is controlled by a floating bell jar behind the screen marked N in Fig. 2. This bell rises or falls according to atmospheric changes, and manipulates a change-speed gear, arranged just behind it, that has an infinitely variable ratio over a range of about 10 per cent. either way. This gear, shown in Fig. 5, is a most ingenious contrivance, but we have not space here to describe it in detail. In broad principle it comprises the insertion of a friction drive between the driver and driven shafts. This friction drive takes place between an inclined disc D—Fig. 5—which is driven off the clockwork by the chain S and sprocket F, and the horizontal cylinder C. Between these two there rests a bronze ball B, that lies between the forked end of a bell-crank lever connected with the bell jar H. When the ball is in the centre of the disc the cylinder remains stationary, but movement of the ball to one side or the other, under the influence of the bell jar, makes the cylinder turn one way or the other. This rotation of the cylinder is added to, or subtracted from, the primary driving speed of the wheel F by means of a planetary differential gear E, and thus a correction is applied to the clock speed so that the spindle M has a speed appropriate to atmospheric conditions, the drum of the meter is moved axially in proportion to the difference between the speeds of the spindle and the drum itself, and the amount of gas delivered to the calorimeter is constant, regardless of the immediate atmospheric conditions. The gas connection between the meter and

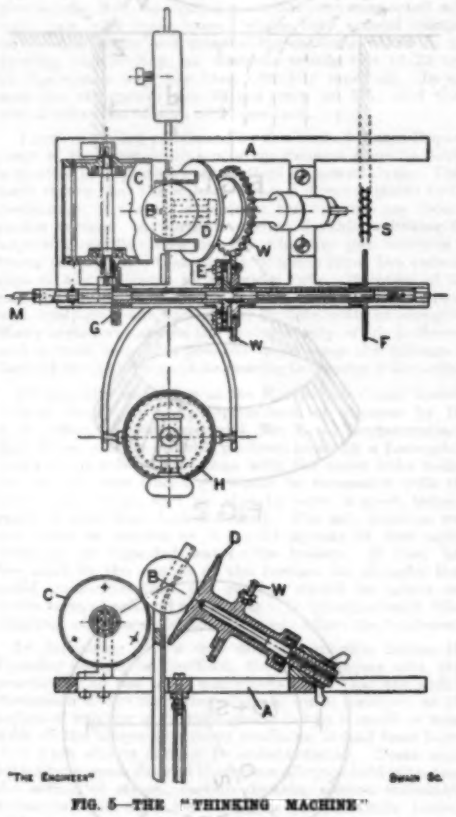


FIG. 5—THE "THINKING MACHINE"

the burner runs across the front of the instrument, and, as will be seen in Fig. 2, includes a manometer to show that the gas is delivered at practically atmospheric pressure.

In conjunction with the speed-regulating gear, which Professor Boys calls the "Thinking Machine," there is a small recording drum O, in Fig. 2, on which the end of the lever that controls the bronze ball makes a mark for registering the movements of the bell jar.

Summarising the essential parts of the apparatus, it may be said to comprise means for dealing out gas under standard conditions in exactly measured quantities at a rate of speed corresponding exactly with a known flow of water, and of apparatus for indicating and recording the rise in temperature produced in the water by the burning of the gas. All the units of the apparatus are interdependent, the failure of any one part is demonstrated by a palpable mark on the record, and it appears to us that all possible contingencies have been provided for in its design.

A small point, but one worthy of consideration, to which we might have referred to before, is the use of the little hot-air engine for circulating and cooling the water. It only uses 1½ cubic feet of gas per hour, while the jet of the calorimeter needs ½ cubic foot per hour, so that the total consumption of the apparatus is 2 cubic feet. It is generally agreed that more gas than this should be burned in order to keep the gas in the service pipe "alive." Another burner has, consequently, to be lit on the same branch as the calorimeter, and the pumping service is thus secured at no extra expenditure of fuel.

Another instrument to which Professor Boys referred to during his Discourse is a "spot-test" calorimeter, embodying the same gas meter and interchanger as that already described, but furnished with mercurial thermometers. This apparatus, he said, will settle down to stable conditions in about 10 min., which is, of course, remarkably quick for a flow meter.

Structure of Alloys.

THE thirteenth annual May lecture of the Institute of Metals was delivered on May 2nd in the Hall of the Institution of Mechanical Engineers, by Dr. W. Rosenhain.

In taking for his subject the structure of alloys the lecturer referred to the important work which has been done during recent years in the accumulation of facts regarding the properties and microstructure of alloys. The time had arrived, he said, when it was most desirable that a key should be found to the maze of knowledge now available in the form of a general theory. He would put forward a theory which he believed was in accordance with the known facts. Metallurgists owed much to the brilliant work in connection with the internal structure of metals which had been done by investigators in X-ray analysis. These investigations had given a large amount of precise knowledge on points concerning which earlier information was largely qualitative. It should not be forgotten, however, that many years before X-ray methods were introduced the truly crystalline structure of metals had been recognised by metallographers, to whom it was most gratifying to obtain the definite confirmation of many of the inferences drawn by cruder methods than X-ray analysis. The net result of X-ray crystal investigations indicated that metallic crystals yielded well-defined diffraction spectra, from which in all the simpler cases the arrangement of the atoms could be determined. The results achieved by this method of investigation could be stated in terms of what were known as "space lattices." A space lattice was merely a system of lines running in three directions in space and crossing one another in a regular manner. At some or all of the intersection points the centres of the atom were located. By laying additional lines parallel to the three original sets and placing atoms upon certain of the additional points of intersection the types of cubic lattice most commonly met in metals were obtained. If, in addition to an atom at the corner of each cube, another atom were placed at the centre of each cube face, we got the face centred cubic lattice, which was characteristic of certain metals. If, instead of atoms at the centres of the cube faces, an additional atom was inserted at the centre of the cube, the body centred cubic lattice, also found in metals, was produced. More complex types of arrangement were to be anticipated in the case of inter-metallic compounds, the exact structure of which had not yet been worked out. Under conditions of thermal agitation the atoms oscillated about the equilibrium positions with a corresponding expansion of the lattice, which at a certain point broke down the inter-atomic linkage and formed a new phase, in which the lattice disappeared more or less completely, the new phase being liquid in some cases, while in others the new phase might be a crystalline solid with a different space lattice. It was necessary, in order to obtain a clear idea of the nature of the atoms and the mechanism of linkage, to adopt either the theory of Langmuir or the Bohr-Rutherford model of the atom and to realise that an atom which in a state of equilibrium came to rest upon a definite space lattice must have strongly defined directional properties, which for brevity might be termed "bonds." With this conception of the atoms and their arrangement on the space lattice in mind it was possible to form a picture of the internal structure of a crystal. It was necessary, however, to consider the case, not of the crystal composed entirely of atoms of one kind, but of a more complex type of crystal, i.e., that of a solid solution alloy. Even in such circumstances the general organisation of the crystal remained much the same as that of a pure metal, and it was necessary to find room for the solute atoms in such a way that their presence affected, but did not destroy, the crystalline organisation. It was possible to imagine the solute atoms being introduced in several ways, but he had adopted the view that the solute atoms were placed upon the actual space lattice of the solvent metal in simple substitution for the atoms of the solvent. This view was confirmed by X-ray measurements and was not at variance with the theory recently put forward by Tammann.

His (Dr. Rosenhain's) theory made it possible to explain in a simple manner many of the most striking properties of solid solutions, and to deduce the constitution and properties of alloy systems from known data of the properties of the constituent atoms. It was obvious that the substitution of an atom of solute for an atom of solvent in the space lattice of a metallic crystal must have a profound effect upon the space lattice in the vicinity. If the fundamental conception were accepted that in metallic solid solutions the solute atom replaced atoms of the solvent on the

normal space lattice of the latter, and that a local distortion as well as a general change of average lattice scale accompanied the distortion, a number of interesting inferences might be drawn. The amount of distortion which a lattice underwent would determine the extent to which certain properties of the crystal, including its hardness or resistance to plastic deformation were affected. It was known that plastic deformation was due to a process of slip, and that if the arrangement were distorted there would be an increase in resistance to slip, so that a slightly distorted lattice would imply an increased degree of hardness and strength and a diminution of ductility. It followed that if the power of a solute atom to cause distortion of the lattice were closely related to the hardening effect, the power of producing distortion determined the limiting solid solubility of one metal in another, and the hardening effect of one metal on another was inversely related to this characteristic. The greater the range of solid solutions formed the less the hardening effect of the added metal per atom added. A study of alloy systems in which the limits of solid solubility had been determined showed that this generalisation held good. In the case of alloys of copper, the hardening effect within the range of solid solubility of alloying metals was in the following order: nickel, manganese, zinc, aluminium and tin. A similar rule held for the alloys of aluminium, and, indeed, for the alloys of iron, in so far as they had been studied apart from the disturbing effect of carbon. A new general principle governing the properties of solid solution was thus suggested.

There was another property of solid solutions even more typical than hardness which could be explained on the basis of the substitution theory. It was the lowering of the melting point and the spreading of melting and freezing over a range of temperature. It was a natural inference that slight local distortion of the lattice was more likely to occur in the harder and stronger metals possessing high melting points, a consideration which at once connected strength and hardness as well as high melting point with the tendency to form long ranges of solid solutions. The high melting metals, such as iron, nickel, cobalt, chromium, copper, silver and gold, were all known to form alloy systems mainly consisting of solid solutions. The metals with lower melting points, like zinc and aluminium, formed a more limited series of solid solution, while the soft low-melting metals, like lead, tin and cadmium, showed alloy systems which tended to approach the entirely eutectiferous types arising from very slight solid solubility. This theory gave explanations of a number of well-ascertained facts. It would seem that it should be possible to utilise the data obtained from solid solutions to determine the constants of the atoms, a line of research which opened up the prospect of being able to predict by calculation the entire properties of an alloy system.

Another interesting fact which emerged from the work which had been done was that the conception of lattice distortion by the introduction of solute atoms threw light on the electrical behaviour of metals and alloys, and would assist the process of arriving at a satisfactory theory of electrical conduction in metals. The effect was best explained by a simple mechanical analogy. In the case, for example, of a row of perfectly elastic uniform spheres in true alignment, an impulse delivered to one end of such a row would be transmitted without loss to the other end, whereas if the row were slightly out of alignment or one of the balls of a different size, the impulse would no longer be transmitted without loss. In the case of an electrical impulse, something was transmitted through the rows of atoms and the transmission was associated with the movement of electrons. In a perfectly uniform space lattice in which the atoms were at rest, resistance was negligible, but when the atoms were disturbed by thermal oscillation the resistance increased in a manner analogous to what happened when disturbing conditions were present in the row of spheres. The introduction of solute atoms in a solid solution produced distortion, and this accounted for the very high resistance of solid solution alloys. Thermal oscillation was superimposed upon a lattice already disturbed by the solutes, and hence the lower temperature coefficient of electrical conductivity in alloys, as compared with pure metals. The super conductivity of pure metals at very low temperatures was readily understood on this basis, as well as the phenomena found in some metals when cooled down to a few degrees above absolute zero. This theory was in accordance with the observed fact that impure metals had not yet been brought into a condition of super-conductivity. It was interesting to note, too, that this explanation accounted for the striking parallelism which existed between electrical conductivity and mechanical ductility in metals, and indeed in substances generally.

THE annual report of H.M. Chief Inspector of Mines for 1921 shows that the change-over from oil-flame to electric lamps was progressing at a rate approaching 22,000 per annum. Towards the end of 1921 there were 605,566 oil-flame lamps—Davy—and 268,538 electric safety lamps in use in the coal mines of the United Kingdom. By the end of the year 1922 probably as many as 300,000 electric lamps had taken the place of an equal number of Davy lamps.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE LIFT OF A BALL VALVE.

SIR,—It is well known that the minimum lift for a poppet valve, *i.e.*, that necessary to give an area of opening equal to the area of the passage to be closed, is equal to one-quarter of the valve diameter, if the bevelled seating be neglected. The requisite lift for a ball valve does not, however, appear to be generally known; its determination is a much more lengthy proposition, and is not to be found in the usual text-books.

Referring to Fig. 1, the area through which the fluid passes

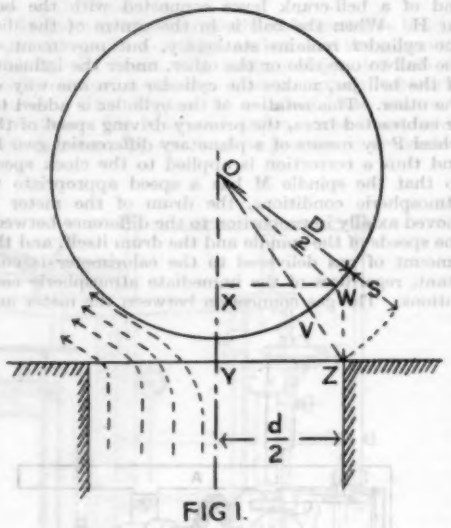


FIG 1.

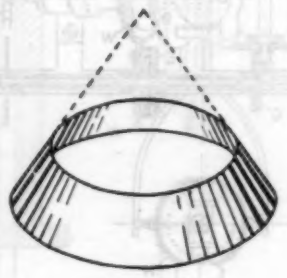


FIG 2.

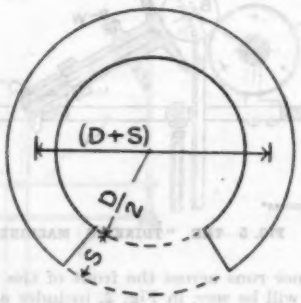


FIG 3

is the surface of the conical frustum whose slant height is V Z—this area is shown in perspective in Fig. 2, and its development in Fig. 3, and it must equal the value of $\frac{\pi}{4}d^2$ to obtain the minimum requisite lift.

From Fig. 3 the area of the complete annulus $= \pi\,(D + s)\,s$, the outer circumference of complete annulus $= \pi\,(D + 2s)$, and the outer circumference of the annular sector = the circumference of the seating $= \pi\,d$.

$\therefore$ the surface area of the conical frustum $= \dfrac{\pi\,d\,(D + s)\,s}{D + 2s}$

Equating this to the required area $\frac{\pi}{4}d^2$

$$\frac{\pi\,d\,(D + s)\,s}{D + 2s} = \frac{\pi}{4}d^2$$

whence

$$\frac{s\,(D + s)}{D + 2s} = \frac{d}{4} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

which is a quadratic equation in s, of which the solution is

$$s = \frac{d}{4} - \frac{D}{2} \pm \frac{1}{2}\sqrt{D^2 + \frac{d^2}{4}} \quad . \quad . \quad . \quad . \quad (2)$$

in which only the positive square root is admissible, as the second term is always greater than the first, and s can only be positive.

It is convenient to replace the ball diameter D by the term $k\,d$, where k is the ratio of ball diameter to diameter of opening.

Then the equation (2) reduces to

$$s = \frac{d}{2}\left(\frac{1}{2} - k + \sqrt{k^2 + \frac{1}{4}}\right) \quad . \quad . \quad . \quad . \quad (3)$$

Referring to Fig. 1, the lift $= XY$
$= OY - OX.$

Now $OY = \sqrt{OZ^2 - YZ^2}$

$$= \sqrt{\left(\frac{D}{2} + s\right)^2 - \left(\frac{d}{2}\right)^2}$$

Substituting $k\,d$ for D, and the value for s from equation (3), this reduces to—

$$OY = \frac{d}{2}\sqrt{k^2 + \sqrt{k^2 + \frac{1}{4}} - \frac{1}{2}} \quad . \quad . \quad . \quad (4)$$

$$OX = \sqrt{OW^2 - XW^2}$$

$$= \sqrt{\left(\frac{D}{2}\right)^2 - \left(\frac{d}{2}\right)^2}$$

which reduces to

$$OX = \frac{d}{2}\sqrt{k^2 - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

From (4) and (5)

$$\text{lift} = XY = \frac{d}{2}\sqrt{k^2 + \sqrt{k^2 + \frac{1}{4}} - \frac{1}{2}} - \frac{d}{2}\sqrt{k^2 - 1}$$

$$\therefore \text{lift} = \frac{d}{2}\left(\sqrt{k^2 + \sqrt{k^2 + \frac{1}{4}} - \frac{1}{2}} - \sqrt{k^2 - 1}\right) \quad (6)$$

When k becomes very large, approaching infinity, then the terms $\sqrt{k^2 + \frac{1}{4}}$ and $\sqrt{k^2 - 1}$ each approach the value k, so that the bracket reduces to $\left(\sqrt{k^2 + k - \frac{1}{2}} - k\right)$, in which the $\frac{1}{2}$ may be neglected in comparison with $k^2 + k$, giving a further reduction to $(\sqrt{k^2 + k} - k)$. When k is large, $\sqrt{k^2 + k}$ is practically equal to $k + \frac{1}{2}$.

Thus when k is very large—*i.e.*, the ball surface becomes so flat as to be a flat valve—the minimum lift required is

$$\frac{d}{2}\left(k + \frac{1}{2} - k\right) = \frac{d}{4},$$

the condition for the poppet valve.

Values of the factor

$$\frac{1}{2}\left(\sqrt{k^2 + \sqrt{k^2 + \frac{1}{4}} - \frac{1}{2}} - \sqrt{k^2 - 1}\right) = c$$

say, are given in the table below, from which the minimum lift can be deduced for any required case; intermediate values can be interpolated from a curve plotted from the tabular figures.

Minimum Lift of a Ball Valve.

Lift $= c \times$ diameter of opening.

$$k = \frac{\text{ball diameter}}{\text{opening diameter}}$$

k	1	1.04	1.1	1.2	1.4	2.0
c	.636	.53	.463	.416	.368	.313

April 27th. C. B. CLAPHAM.

HENG-CHOW COMPANY, LIMITED—CHINA MINES.

SIR,—As one deeply interested in the development of Chinese enterprise, I am glad to see that the "China Mines" case has at last been brought to a conclusion after a trial lasting nine days, and that any cloud which may have shadowed the Heng-Chow Company has been entirely dispelled. His lordship said, in his summing-up, that there was no question whatever of the *bond fides* of this company or of the rights which their agent and engineer, Mr. Grant, has obtained; in fact, he observed that it was because these rights were so good that the "fraud" was possible.

May I take the opportunity, Sir, of bringing this to your notice. It is a matter of great importance that undertakings which are endeavouring to develop British trade in the Far East, especially in mining and engineering matters, shall not be handicapped by misrepresentation, repeated not only in the British Press, but also copied into the China newspapers, both foreign and vernacular.

CECIL G. HOWSIN,
A.M. Inst. C.E., M.I. Mech. E., M.I. Loco. E.

London, May 1st.

CORROSION.

IN a leading article in our last issue we used as an example the case of the failure of certain condenser tubes. The information in our hands at the time was scanty and incomplete, and, in consequence, we presented an inaccurate explanation of the failure. Since writing we have obtained more details, but they still leave something to be desired. We hope, however, to be in a position to publish full particulars in the near future. In the meantime we offer the following emendation which has been sent to us:—"The water enters the condenser and passes at great velocity in order to maintain a low temperature and high vacuum. This water passes through the usual funnel-shaped entrance pipe under heavy pressure and, on attaining to the water end of the condenser, this pressure is reduced and the air in solution passes out of the water in the form of a mass of bubbles, resulting in an attack on the tubes—near the inlet end—in the form of a water hammer, this hammer breaking away the protective scale, and allowing the entangled air, in the form of bubbles or foam, to attack the surface of the metal. The air-theorists say the sudden expansion of the water resulting from the cone-mouthed pipe must be stopped, and that the water must be so introduced and deflected that these bubbles do not impinge directly upon the ends of the tubes."

Railway Matters.

THE annual dinner of the Railway Benevolent Institution—a body that gives relief to every class of railwayman—will be held on Tuesday evening next, the 8th inst.

THE London and North-Eastern Railway Company has established a central freight rolling-stock control at York for the control and distribution of freight vehicles for the whole of its system.

THE Railway Amalgamation Tribunal has had before it since Monday the consideration of the terms under which the Caledonian Railway Company will be amalgamated into the London, Scottish and Midland Company.

SOME new automatic ticket-issuing machines at the Metropolitan District Railway station at Victoria have been provided with an electrical contact, which causes a bell to ring in the booking office when the supply of tickets is getting low.

A DRIVER of a train was seized with illness whilst passing through Harecastle tunnel, a mile long, in the North Staffordshire section of the London, Midland and Scottish Railway on Friday last. The fireman supported the man and took charge of the engine and stopped it at the next station. The unfortunate driver died later in the day.

WHEN the Metropolitan Railway Bill was in Committee in the House of Commons the extension of the Great Northern and City Railway to Lothbury was mentioned as a case in which a pre-war estimate of cost was insufficient, and powers to spend more on the line were asked for. This suggests that the extension is shortly to be proceeded with. The Bill was reported for third reading.

WHEN the companies restored week-end tickets they did not revert to the Friday to Tuesday arrangement, but gave only Saturday to Monday. But they did concede that where the fare was 15s. the outward journey might be started after 5 p.m. on Friday. This privilege has now been modified so that tickets for the longer period may be obtained where the fare is as low as 10s.

THE member for the Kelvingrove division of Glasgow drew the attention of the Parliamentary Secretary to the Ministry of Transport, on the 24th ult., to the fact that now that the headquarters of the Scottish railways are domiciled in London, orders for all classes of rolling-stock and railway materials, which were formerly placed in Scotland, are now being given to works situate in England, to the serious prejudice of trade and employment in Scotland. Colonel Ashley replied that this was a question for the commercial discretion of the companies.

ACCORDING to a report in a recent issue of the Norwegian journal *Aftenposten*, the Norwegian State Railways have ordered from Germany three rail cars driven by motor spirit which are to be put on trial this year. One car has been ordered from A.E.G., Berlin, for delivery by December 10th next. This car is fitted with two axles; the other two, which are fitted with four axles, have been ordered from Deutsche Werke, Kiel, for delivery by October 10th. The latter are said to be 19¼ m. long, 2.75 m. broad, 3.85 m. high, and to weigh 18 tons; further, there is seating accommodation for 70 passengers.

THERE have been so many lamentable derailments from wilful obstruction in Ireland that it was natural when hearing that the down mail on the Dublin and South-Eastern Railway had been derailed the other day, to assume that the accident came about from the same cause. The Irish papers show, however, that the accident occurred between Bray station and the northern entrance to the tunnel under Bray Head, and that it was brought about by a fall of rock. This is not that part of the line which it is proposed to carry inland so as to save possible destruction by the sea, as it stands considerably above sea level. The rocks are, however, subject to coast erosion, and we have, when passing through, seen the line in the neighbourhood patrolled.

UNDER Sec. 16 (1) of the Railways Act, 1921, the Railway and Canal Commission, on the application of any body of persons representing the interests of the public or of trade, or the Minister of Transport on application of the railway companies, may, by Order authorise the railways to afford reasonable railway services, facilities and conveniences, including the provision of such minor alterations and extensions and improvements of existing works as will not involve in any one case an expenditure exceeding one hundred thousand pounds." On the 26th ult. a Bill, introduced by the Government to increase the sum named to £500,000, was read a second time. It was said that this would enable railway companies the more readily to undertake works for the relief of unemployment.

AN official statement issued by the Underground states that all estimates of the traffic to the Cup Final on Saturday last were considerably exceeded, but, in spite of this, the train, omnibus, and tram services fulfilled their part without any material delay occurring. On the Underground alone the bookings were 133,530 in excess of a normal Saturday's traffic. The motor-omnibus passengers carried by the special services arranged numbered 30,000, and some 14,000 additional passengers journeyed to the Stadium by privately-hired vehicles. There were 325 of these. By all three traffic agencies 6,000,000 passengers were dealt with on Saturday, which tops last year's Cup Final figures by 800,000. The London, Midland and Scottish carried 75,000 people to the Cup Final.

SPEAKING at Southall on the 27th ult., Mr. C. T. Cramp, the industrial secretary of the National Union of Railwaymen, said as regards the proposed revision of the conditions of service:—"I want to make a suggestion to the companies. They have already made some reduction with which the traders are not satisfied. I suggest to the companies that they put into operation all the cuts which they may have had in mind in freight rates. Let them take that experience for some months, and then come to us with the results and show us what it means. If they do not do that, they are asking us to agree to modifications on the supposition that they are going to suffer loss. Decreased fares and freightage do not necessarily mean a reduction in receipts. I want to see definite proof before I am prepared to agree to any drop."

Notes and Memoranda.

THE three electrically-driven pumps which have just been installed at the Watgunge pumping station for the Calcutta water supply, occupy only the space of one of the two original steam sets. Each of them is capable of supplying 3500 gallons of water per minute, against a head of 140ft., and is operated by a 400-volt motor.

THE joints of a big gas holder which has been erected at South Melbourne, were all made by means of arc welding, and the welders averaged, according to the *Gas Engineer*, 15ft per hour, using 1.5ft. No. 10 electrode per foot on the overhead and horizontal fillets, and 12ft. per hour, using 2ft. No. 10 electrode per foot on the vertical fillets.

IT is estimated that nearly 400,000 horse-power could be developed from the Salmon River, Idaho, at times of low-water flow and nearly twice that amount at times of medium flow. The project suggested for one of the sites contemplates the diversion of the flow of Salmon River into the Snake by means of a tunnel 8 miles long, which would create a head of 430ft.

IN the course of a paper read before the Institution of Production Engineers, Mr. L. C. Keen gave the following advice. Do not attempt, on drills below $^{9}/_{16}$in. diameter, to drill a depth more than three times the diameter of the drill without drawing out to clear the chips; if the drill as well as the work is revolved, however, it can be easily fed in to a depth of five times the diameter at one traverse.

THE new bronze alloy coronium is composed, according to Mr. E. Hall Craggs, of the Brentford Foundry, of copper, 16 parts; zinc, 3 parts; tin, 1 part. With ordinary sand castings tensile tests have given 16 to 18 tons per square inch, according to conditions connected with each case. In some cases, where very special castings have been made and unusual precautions taken in the pouring and cooling, an ultimate tensile test of 22 tons to the square inch has been officially reported. In one case the elongation was 38 per cent. on 2in., and there was a reduction of area of 37 per cent.

TESTS are being continued by the United States Department of the Interior on motor car exhaust gases to devise a method of adjusting carburetters by gas analysis. Tests have shown that the mileage bears a direct relation to the percentage of carbon dioxide in the exhaust gas from a motor vehicle. A portable carbon dioxide indicator for adjusting carburetters on the road by gas analysis is being developed. Connection is made from the exhaust pipe to the indicator by a copper tube. Samples of the exhaust gas are taken while the vehicle is run on the road, and analyses made for carbon dioxide without stopping. Many tests have shown the practicability of the indicator, and in most tests it is possible to increase the mileage at least 25 per cent. without decreasing the power or flexibility.

DURING the discussion at the North-East Coast Institution of Engineers and Shipbuilders, of a paper by Dr. J. T. Dunn, on powdered coal, Mr. E. A. Leybourne said that it was a more difficult problem to equip a Lancashire boiler for powdered fuel than with the water-tube boiler, but he was sure that they would be successful with the Lancashire boiler and be able to burn a much inferior grade of coal than hitherto used. The ash question was not quite so serious as it would appear at first sight, certainly as regarded water-tube boilers. If they had free play in the design of the furnace he thought they could guarantee that the residue would be taken out in the form of ash and not of slag. In his experience, what slagging took place did not adversely affect the brickwork.

IN discussing alloys resistant to corrosion before the Faraday Society at Sheffield, Mr. J. F. Kayser said that practically all the trade pamphlets claim that the nickel-chromium alloys they describe are quite resistant to the action of sulphur in furnace gases, but as a result of trials with all the alloys at present available, it had been found that such claims cannot be substantiated. Tests made with single gases showed that some alloys would withstand the action of steam, carbon dioxide, carbon monoxide, ammonia, and even pure oxygen for indefinite periods without scaling. Mixtures of those gases were also found to be quite harmless upon the alloys. The introduction of either sulphuretted hydrogen or sulphur dioxide—particularly the former—proved, however, to be fatal to even the highest grade nickel-chromium alloy.

AN unusual type of failure of a marine, return-tube boiler is described in one of the latest Board of Trade reports. The boiler was regularly inspected by a marine engineer, and apparently received all proper attention. The accident was caused by one of the tubes inside the starboard nest collapsing on account of wastage. In commenting on the mishap, which fortunately did not result in any fatality, the inspector says that the tubes in the bounding rows were quite free from any wastage, and only those near the centre of the nests appeared to be affected. The wastage had taken place in patches on the bodies of the tubes, under a normal thickness of scale, and having regard to the inaccessibility of the tubes affected, it is not surprising that the corroded parts escaped notice. The remaining parts of the boiler, including the tube plates, were found to be entirely free from pitting.

THE Johnson-Rahbeck effect, that is, the mutual attraction during the passage of a very small current between a conductor and a semi-conductor in close contact, has been utilised in a number of pieces of apparatus. The "electric adhesion" principle lends itself admirably to telegraphy and sound reproduction. A rapid writer for the morse system is described in the continental technical Press. This consists of a semi-conducting cylinder, with a metallic band held in close contact with it over a portion of its circumference by a spring or weight. The cylinder turns slowly, and the passage of a small constant current brings the "electric adhesion" effect into play. Any variation of the current strength will cause a greater or less adhesion, and the metal band will, therefore, "stick" to the cylinder with more or less force as the latter rotates, and will tend to be dragged along with it. The rapid writer has a bell-crank and pen attached to the metal band, and can be operated at speeds up to 3000 morse letters per minute.

Miscellanea.

THE fifth of the eight units of the Chippawa development of the Ontario hydro-electric system was put in operation on April 9th, bringing the total capacity of the plant up to between 275,000 and 300,000 horse-power.

THE proposed extensions of the electric generating plant of the Worthing Borough Council are to include a heavy oil engine and dynamo set, of a capacity of 750 kilowatts, a 15-ton overhead travelling crane, centrifugal motor-driven circulating water pumps, with piping, tanks, &c.

AN association of large users of brass and copper has been formed to secure their co-operation and to promote the welfare and interests of members in relation to supplies of sheet and strip brass and copper. Manufacturers using 140 tons per annum, or more, are eligible for membership. The secretary is Mr. P. P. Richards, Box 18, Chamber of Commerce Buildings, Birmingham.

THIS year the Rio Tinto Company attains its jubilee, but the mine from which it takes its name is the most ancient of the great copper mines now working, much older than the Stora Kopparberg in Sweden. The company's property is situated in the south-west corner of Spain, near the Portuguese boundary, 51 miles by rail from the seaport of Huelva, and it contains five different mines. Copper appears to have been mined at Rio Tinto in the earliest ages, and it is certain that the Phœnicians dealt in the ores and worked the mines with no little skill more than a thousand years before the beginning of our era.

THE value of the new aluminium produced in the United States during 1922 is reported as 13,622,000 dollars, an increase of about 25 per cent. over the value in 1921. Exports of aluminium during 1922 included 1,538,079 lb. of ingot and scrap aluminium and alloys containing aluminium, 2,808,946 lb. of plates, sheets, bars, strips and rods, and 4,548,939 lb. of manufactured articles, which represents a very large increase over the amount exported during the previous year. Imports, on the other hand, also increased to 31,482,983 lb. during the early part of 1922, as compared to 26,177,852 lb. for the corresponding period in 1921. This amount includes aluminium in crude form, scrap and alloys of any kind in which aluminium is the material of chief value.

FOLLOWING on discussions which have taken place during the last few months between the Society of Motor Manufacturers and Traders and the Ship and Boat Builders' Association, Limited, it is announced that an agreement has been reached on a comprehensive basis for the closest possible co-operation between the two Associations, both in relation to exhibitions of marine and stationary engines and marine craft, and also as regards political and general matters of mutual interest to engine manufacturers and hull builders. A joint committee of both bodies will be set up at once, and the first subject for consideration will be to co-operate as regards the general scope of and arrangements for, the marine exhibit in connection with the Shipping, Engineering and Machinery Exhibition at Olympia in September next.

THE Malay States Information Agency, London, is authorised to announce that an agreement has been arrived at between the parties to the Bandoeng Agreement—whereby certain stocks of tin were withheld from the market—for the disposal gradually of the stocks at the rate of 5 per cent. per month, with effect from April 1st. Each party is free to sell or to hold the amount thus released. The total amount of tin involved being 17,600 tons, the amount released will be at the rate of 880 tons, and a period of twenty months will elapse before complete release is effected. The agreement may be varied later respecting the amount released monthly to each party, but if it is, a public announcement will be made by the parties before the variation takes effect.

IN order to relieve the shortage of electric power, which is seriously crippling the mining industries of Northern Ontario, the Provincial Government of Quebec decided to sell at auction on April 25th a lease of the Des Quinze Rapids at the head waters of the Quinze River, which are stated to be capable of generating nearly 100,000 horse-power of electric energy. The upset price was to be an annual rental of 8000 dollars, and the company securing the lease will be bound to develop at least 20,000 horse-power within four years. The Government has adopted the principle of charging a royalty of 50 cents. per horse-power on all electricity exported from the province, which will apply in the case of this and all future leases, but not to leases of water powers previously granted.

IT is reported from Bergen that a Norwegian engineer has just completed successful experiments with a device for converting an ordinary motor cycle for use over snow. The front wheel of the motor cycle is removed, and by means of four long strips of springy steel which form a fork, it is placed about a yard behind the back wheel. The tires are removed from both wheels, and a flat balata belt fitted with narrow strips about ¾in. thick is run over them. This belt is in constant contact with the snow surface. In place of the front wheel a light and narrow sledge is fitted in the steering head. During tests over a flat snow field a speed of over 50 miles per hour has, it is said, been obtained, and a 1 in 6 gradient of smooth snow has been climbed with ease. Further tests over rough mountain snow fields, frozen snow, and melting snow are reported to have given great satisfaction.

THE Government of the State of Chihuahua, Republic of Mexico, has granted a concession to the Compañia Agricola y de Fuerza Eléctrica del Rio Conchos (S.A.) to extend the power lines from its present hydro-electric plant, situated at Boquilla (near Ciudad Camargo, generally known as Santa Rosalia), in the State of Chihuahua. The contract calls for the supply of power to the near-by smelters and adjacent mining camps. The concession extends to the year 1941, and provides for an increasing scale of taxation to meet costs of installation. Maximum rates are to be charged for various classes of electric power, but only such as will form no burden upon the community employing it. The high-tension lines to be constructed will each be approximately 90 miles in length, the entire work, including towers, relay stations, transformers, &c., costing approximately 1,400,000 Mex. dollars (£140,000).

THE ELECTRIFICATION OF THE RHAETIAN RAILWAYS

(For description see page 464)

FIG. 10—THE KUBLIS POWER STATION AND PIPE LINE

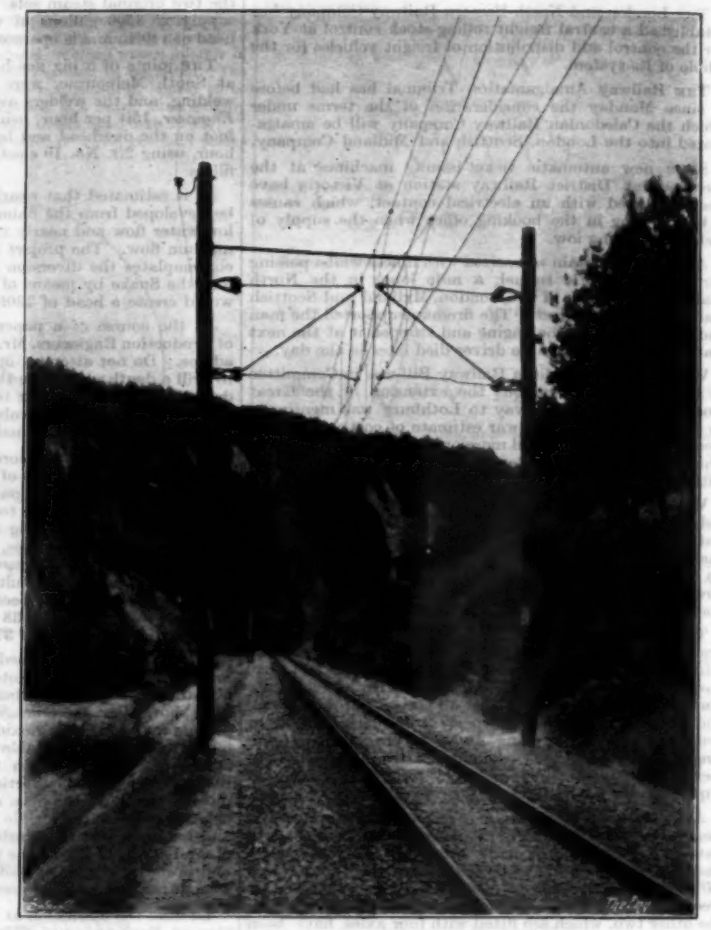


FIG. 11—SECTIONISING POINT ON THE REICHENAU-DISENTIS LINE

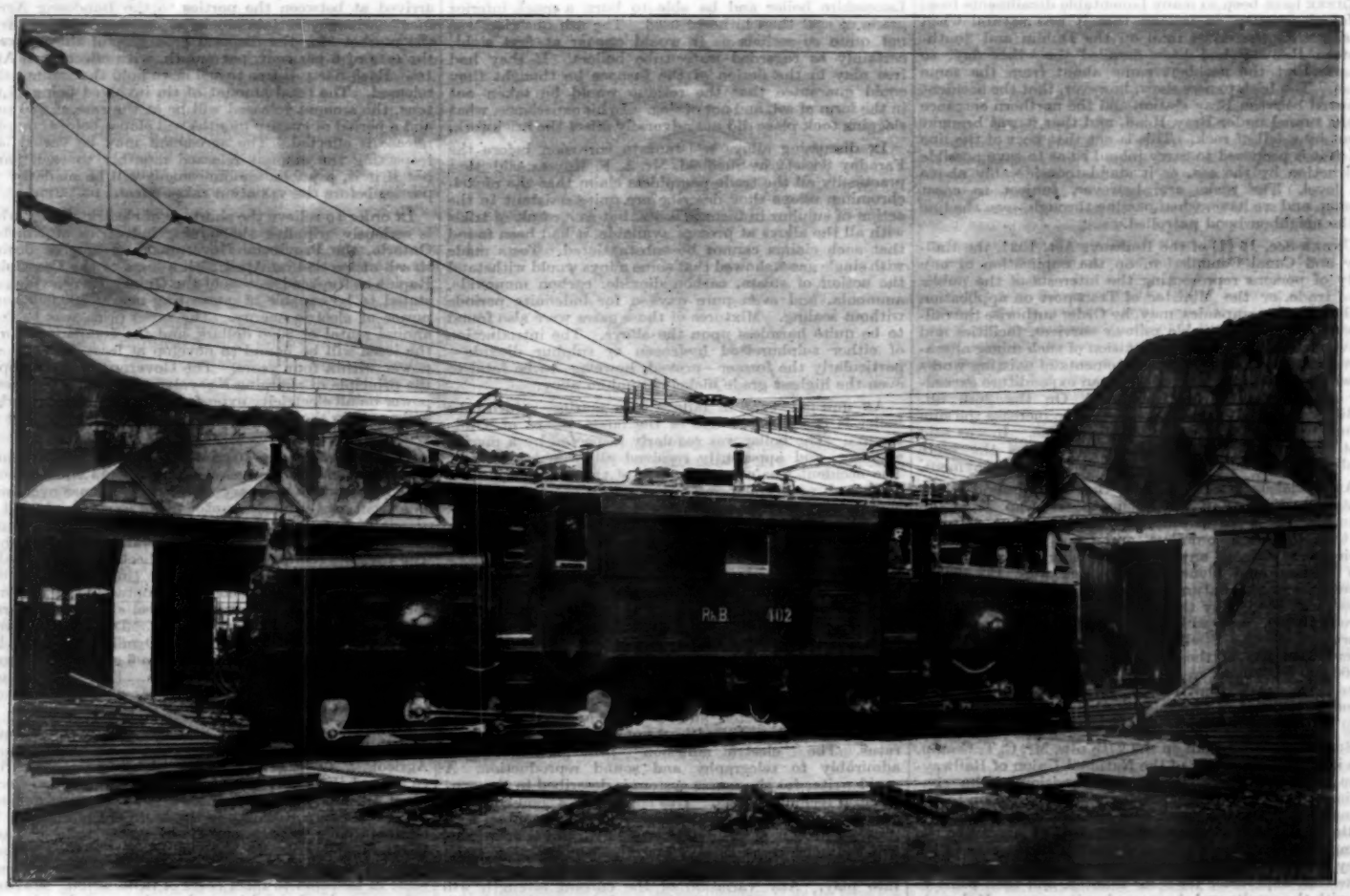


FIG. 12—OVERHEAD NETWORK ABOVE TURNTABLE AT LANDQUART LOCOMOTIVE SHEDS

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SOUTH AMERICAN BRANCH OFFICE OF

The Engineer,

526, Bolsa de Comercio, Buenos Aires.

SUBSCRIPTIONS.

THE ENGINEER can be had, by order from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from this office.

Half-yearly (including index number) .. £1 12s. 6d.
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THE ENGINEER.

MAY 4, 1923.

The Internal Combustion Turbine.

FROM time to time during the last twenty years or more the question has arisen as to whether or not a turbine working on an internal combustion cycle is a practicable proposition, and though a number of experimenters, who have attempted to solve the matter by actual test, have not succeeded in arriving at any satisfactory result in the way of efficiency comparable with that of contemporary prime movers of other design, it is largely owing to full appreciation of the circumstances surrounding these failures, particularly when viewed in the light of subsequent improvements in design and material, that the matter still possesses no small degree of attraction, and, although the subject has been somewhat neglected during recent years, some very striking advances have been made in gas turbine design. The question which requires consideration is no longer whether it is possible to construct a reliable working machine—that may be taken for granted if the matter is left in the hands of competent designers—but whether the efficiency, which recent designs appear to offer, is sufficient to bring the gas turbine into the market as a practical and economical prime mover. The articles which begin to-day in our columns have been written with the idea of placing within a small compass a review of what has already been accomplished and the reasons why these attempts have failed, and of showing the direction in which developments may be expected, as well as their limitations. The pure self-contained gas turbine *independent of all water supply of any kind* is far from being too ideal an engine to contemplate. It is a feasible proposition to-day even with present materials, but its efficiency will be low, and it will necessarily prove less economical than one in which both steam and gas are utilised, and it also possesses certain disadvantages in the way of starting and governing. An overall thermal efficiency—ratio of heat equivalent of effective work to heat units supplied—of 25 to 28 per cent. appears to be about the practical limit of what can be accomplished to-day in internal combustion turbine design. This limit is imposed by the fact that the temperatures of the working fluid are such that the strength of the materials of construction, and particularly that of the rotor wheel, which is necessarily the most highly stressed portion in a turbine, is very considerably reduced. But while higher mechanical efficiency is not likely to be obtained until very great improvements in the heat-resisting qualities of material are made, comparatively small advances will gradually enable cycles of higher absolute thermal efficiencies to be utilised. Thereby a direct step-by-step improvement in the overall efficiency will carry us forward until such time as a better rotor and blade material will admit of the use of single-row wheels in lieu of the inherently less efficient velocity compounded wheel. These small advances may be made either in the way of a higher impinging temperature or of higher blade velocity or of both.

The gas turbine depends upon a large range of specialist knowledge for its ultimate solution. It is but very partially a turbine problem. Even granted turbine efficiencies equal to those of the best impulse steam practice, with a velocity-compounded wheel one is restricted to an energy conversion of less than 70 per cent., and even when this figure is obtained, very expert skill in the matter of air-compressor or exhauster design is needed to reduce the negative work involved to its lowest possible quantity. And this combination of talent is insufficient, for it is mainly on the work of the metallurgist that gas turbine and compressor design must rely for future improvements. When the development of the steam turbine called for material for large disc wheels running at high peripheral velocities a good deal of experiment was necessary even before the now usual 5 per cent. nickel steel of low carbon content was eventually evolved. For the temperatures necessary for efficient gas turbine working, we must look in the direction of composite steel alloys. Chromium, tungsten, vanadium and molybdenum have all been experimentally used, but the results nearly all require further research before their reliability can be accepted as adequate for gas turbine rotors. Some of the alloys are difficult to work, others tend to develop cracks after a time, and it must be remembered that compared with steam turbines the danger of setting up undue internal strains when starting up or shutting down is very much magnified in the internal combustion turbine. Neither in constructional features nor in the problem of attaining high efficiency is the gas turbine a simple matter. The field which would apparently be open to a satisfactory solution seems to be a very wide one, and much of its importance lies in the influences which it may bring to bear in other directions. The utilisation of the residual gases in the case of low-temperature coal carbonisation, which is being considered in Germany for power supply purposes, is a case in point. Compared with the large oil or gas engine, the gas turbine possesses many important advantages to offset its lower thermal efficiency. It is essentially a very simple machine. Owing to the high revolutions permissible, size, weight and cost can be very much reduced, both of the turbine itself and of the generator driven by it. As far as can be seen from designs already prepared, as well as by deduction from steam practice, there need be no reasonable limit to size of unit—Holzwarth has published designs of a 10,000-kilowatt machine. We may recall that when the first Parsons condensing turbine was built in 1892—a little machine of 100-kilowatt output—few indeed foresaw that by 1912 machines of 25,000 kilowatts would be installed, still less the 40,000 and 50,000-kilowatt sets which have succeeded them. This quality of unrestricted output per machine offers distinct scope in the utilisation of blast-furnace or coke oven gases. The plant in this case would work almost entirely on a sub-atmospheric cycle, the furnace gases being led directly to the combustion chamber without the interposition of any inter-cooler, and with, therefore, a distinct saving in heat from this omission. For marine work there is less scope, except where high power on low weight is needed, and in any case it seems probable that the gas turbine would have to be utilised for some form of electric drive. For many plants where the installation of an engine means that of a boiler and condenser as well, there are many parts of the world in which such a unit would be suitable. Inspection of the tables relating to the absolute thermal efficiency of the various cycles and the ratios of positive to negative work in each case which we shall give serves to show very clearly the superiority of the sub-atmospheric cycle. Ideal, perhaps, as these figures may be, considering that air is taken as the working fluid and the value of the specific heat is assumed to be constant, it must be remembered that although the use of an actual working medium, such as the product of oil combustion, will reduce the efficiency values shown, nevertheless, the value of the heat in the rejected gases is more than sufficient in most cases to counterbalance this reduction. Holzwarth uses it to raise steam for the purpose of driving his compressor and exhauster, but as in all gas engine practice in which regeneration is employed, it may be used in various ways. Armengaud injected this steam into his combustion chamber and lost

the water in the exhaust gases. The objection to passing the steam into the products lies mainly in the opportunity thus given to the sulphur content in the fuel to form first sulphurous and then sulphuric acid, though the extent to which this reaction will occur in the presence of an overwhelming quantity of inert gases—nitrogen and CO_2—is still unknown. This is merely one of the practical difficulties which is likely to be encountered in the early stages of the development of the internal combustion turbine. The furnace conditions of a super-atmospheric constant-pressure turbine will be unlike those of any other furnace problem as soon as the pressure begins to rise. The nozzle design is a little conundrum by itself, for the laws governing the flow of very high-temperature mixed gases through an orifice are not yet investigated, and there is ample room for a long process of trial and error here. Holzwarth's experiments on this point are interesting reading. Apart from the question of what temperature the nozzles will withstand, a more difficult one arises over the blading and what degree of impinging temperature the thin edges will resist indefinitely. In many ways, however, the blades seem to offer easier means of solution than the problem of the rotor at high velocities and high temperatures. The answer can only be that one never knows until one tries.

Application to the problem is undoubtedly one of the best means of solving it, and the fact is that hitherto the lack of demand has neither necessitated nor encouraged research in this particular direction. One of the most remarkable features of the early development of the steam turbine was that, as little or nothing was to be learnt about the subject from current literature, a great amount of work required to be done in every direction appertaining to all forms of applications of the new engine. The great part of this work was of a thoroughly basic nature, and once the principles were grasped and established they became generally applicable to all turbine work. A large proportion of the difficulties which may be anticipated in the case of the gas turbine have already been encountered to no small extent in the course of the evolution of the numerous types of the steam turbine, and many of them assume an aspect of a far less serious nature when viewed in the light of experience with the heavy oil engine or the turbo-compressor. All this accumulated knowledge is available to-day. It was largely lacking twenty years ago when Armengaud and many others began experimenting with the internal combustion turbine.

A Broken Axle.

On December 4th of last year the 10.20 a.m. down express from Euston to Liverpool met with an accident near Castlethorpe Station. It was travelling at high speed when a violent lurch of the engine threw the driver and fireman off their balance. As soon as he could recover his position, the driver shut off steam and applied the vacuum brake, but the train ran 1226 yards before it came to a standstill. On examination it was then found that the tire of the right-hand intermediate driving wheel had gone and that some of the spokes with part of the rim of the same wheel were missing. Furthermore, the leading and driving wheel on the same side was re ting with its tire in the four-foot way and leaning against the inside of the engine framing. The axle had broken off short just within the boss of this wheel. It is a remarkable fact that no part of the train was derailed and no one was hurt. All the evidence, as presented in Colonel Pringle's report to the Ministry of Transport, issued a few days ago, indicates that the first part to fail was the axle, and that the further injury done to the engine and permanent way was caused by the slogging of the driving wheel as it was hauled along by the coupling-rods which still held, though much distorted. It is probable, as the evidence of Mr. George Hughes suggests, that the coupled wheels were locked by the accident, and that the bogie wheels alone revolved. It was owing, he thinks, to that cause that the engine, happily, kept the rails. Had it been derailed at the speed at which it was travelling, there would undoubtedly have been great loss of life and destruction of material. That the train should have run as far as it did after the first indication of the accident is not quite so remarkable as at first appears. It weighed in all nearly two hundred and ninety-two tons, and was travelling at sixty miles an hour. Had it continued at that speed, it would have covered the 1226 yards in about forty seconds. The driver was, as we have said, knocked off his balance by the first lurch, and an appreciable time must have passed before he recovered sufficiently to close the regulator and apply the brakes. Moreover, if we accept Mr. Hughes's view that the coupled wheels ceased to revolve, they would have slid along the rails with very little resistance, so that it is probable that when the driver applied the brakes the speed was still high and that the resistance of the engine was very low.

Fortunately, broken locomotive axles are rare, for of all engine accidents there are few more likely to lead to serious consequences and none more difficult to prevent by inspection. The locomotive builder is practically in the hands of the steel maker, for although he himself may make mistakes in production, they are hardly likely to escape observation, whilst no means have yet been found of discovering a hidden flaw in an axle, and reliance must still be placed upon the physical and chemical tests of small specimens cut from the material. Both Captain Beames and Mr. Ryder, of the Crewe Steel Works, referred to an optical apparatus which is now being tested, but as Mr. Hughes pointed out, even it could not be expected to reveal a defect in an axle concealed within the boss of a wheel. In such cases, then, the engine builder has nothing to guide him but such knowledge of the suitability of the material as may be derived from the physical tests and chemical composition. In this instance, the steel is condemned by the report of the National Physical Laboratory, which found an excess of sulphur and phosphorus, and considered that the material had been rendered brittle by overheating. Colonel Pringle says in his conclusion that the "fractured surface has the appearance common to a failure due to fatigue." We assume that he refers to the coarsely crystalline fracture which for many years was held to be associated with "fatigue," but which the experts, we believe, always attribute now to wrong heat treatment. The point is one of more than verbal interest, for whereas Captain Beames and Mr. Ryder admit that the examination of the metal adjacent to the fracture showed that the analysis of the steel was not as specified and that segregation had occurred, they say nothing about heat treatment; the National Physical Laboratory, on the other hand, says specifically that the test pieces were coarsely crystalline, a "type of fracture typical of *overheated* steel." It adds further: "Chemical analysis shows that the steel possesses an unsuitable composition; in particular, the sulphur and phosphorus contents are too high. Sulphur printing and etching with a cupric reagent show that the steel is seriously segregated. Microscopic examination has revealed serious overheating at some period during the manufacture of the shaft, the harmful effects of which have not been eliminated by subsequent treatment, owing to the temperature of the later heat treatment being insufficiently high to produce complete recrystallisation and refinement of the steel." There is not a word here about "fatigue," and with reference to the alternating stress tests carried out at Teddington, the Laboratory says no more than that "the fatigue range is slightly low when compared with ultimate stress." All this would seem to indicate that, in the view of the National Physical Laboratory, whilst the material was unsuitable for axles, it failed mainly because of incorrect heat treatment. We should have welcomed an expression from it of its opinion as to what would have happened had the steel been properly normalised. Would the axle have been still running, or were the chemical composition and the segregation sufficient to lead to its early failure? Here, again, the point is of practical importance, because taken as a whole the physical tests of the *outer* part of the shaft, the part that failed first, are not bad. A tensile test near the outside showed an ultimate stress of nearly 38 tons, with 30.4 per cent. elongation, and a bend test from the outside went to 145 deg. before fracture. On the other hand, the inside tests were bad, and the condition of the material in that area showed obvious signs of piping.

With the report before us we cannot but feel relieved that the railway company has now withdrawn all axles made from the same cast of steel, that greater care is now being taken at Crewe to insure that the chemical composition of steel follows the specification, and that the percentage of the crop has been raised from fifteen to eighteen. With these precautions, repetitions of such failures should be prevented, if at the same time due attention is paid to the heat treatment. Yet we must admit that the metallurgical explanation does not completely satisfy us. It appears to be admitted that the total stress upon the part that failed was no more than 3 tons per square inch *on the whole area*, equivalent to a factor of safety of nearly twelve. The ultimate stress borne by the outer test pieces was, as we have seen, nearly 38 tons. The margin would appear to be adequate for all purposes, and suggests that either an original flaw existed near the surface of the seat or that a scratch was made during machining or at some other time before the wheel was pressed on to the shaft. Failures of axles at wheel seats are less common than failures at pins, but the impossibility of discovering them before they have caused serious damage should lead engineers, not only to give the closest attention to the quality of the steel, but to consider whether the method of machining or any steps in the subsequent course of manufacture might with advantage be modified.

Town Transport.

By H. M. SAYERS.

The substitution of a trolley omnibus service for a tramway service on the Nechells route of the Birmingham Corporation tramways is a noteworthy event from several points of view. It may be taken in some quarters as an additional argument for the proposition that "the electric tramway is obsolete," and the circumstances of this particular case are indeed such as to suggest that the economic range of the tramway—as expressed by frequency of service—is more limited than has been generally supposed. The particular circumstances must be carefully examined to see how far that suggestion is justified. The more salient and important deduction is that the case is a justification of electric traction as against petrol traction for the conditions. The Birmingham tramways maintain considerable petrol omnibus services, so that the choice of the trolley omnibus was made with full knowledge of petrol omnibus costs, advantages, and disadvantages.

So far as electricity supply is concerned, the trolley omnibus consumes more energy per car mile for equal carrying capacity than the electric tramcar, so that the substitution in this and any other case rather increases the *rôle* of electric energy in the business of town passenger transport.

The circumstances which led to the selection of the trolley omnibus for the Birmingham–Nechells route were various. Some of them arose from war and post-war conditions, and may be reckoned as fairly general, some of them appear to be special. Hence it is not safe to infer that because in this case it was found advisable on economic grounds to displace a five-minute tramway service by a trolley omnibus service, the economic range of tramways is limited to routes requiring a smaller headway than five minutes.

The general conditions above referred to are that in consequence of the war and its immediate after effects the regular maintenance of tramway tracks was perforce interrupted. Permanent way material and labour were both scarce and dear. Material was for a considerable time strictly rationed or totally unobtainable. The result was that after the war many tramway tracks which under normal conditions would have been maintained in serviceable condition at a reasonable cost were worn out and required entire reconstruction. The very high price of both material and labour which had to be reckoned with made this a very expensive matter. No increase of fares could be contemplated which would balance the increased annual charges, not only because of the legal difficulties—partly removed by special legislation—but also because of the universal experience that fare increases reduce traffic. These considerations are of very general application to all British tramways, and it is notorious that tramways have had a bad time—from which, however, there are signs of recovery—during the last four years.

In the case of the Nechells route at Birmingham there seems to have been some special conditions which brought about the selection of the trolley omnibus instead of the reconstruction of the tramway.

Figures published with the authority of the Tramway Department give the estimated cost of reconstruction of the tramway concerned as exceeding by £54,000 the cost of establishing the omnibus service, leading to an estimated annual deficit of about £3000; whilst the trolley omnibus service was estimated to produce an annual surplus of about the same amount. Taking the cost of the 12 omnibuses at about £2500 each, and that of the alterations to the overhead work at £3000 (the figure mentioned by the Corporation tramway engineer to a party which inspected the work on January 31st), it appears that the reconstruction of the tramways must have been estimated to cost something between £80,000 and £90,000. This figure is somewhat guesswork, because it has not been stated whether the cost of removing the tramway track and reinstating the street paving was or was not included in the estimate of establishing the trolley omnibuses. It probably was, as it certainly should have been, and would leave the tramway reconstruction estimate at about the lower figure above mentioned.

Now the trolley omnibus route actually worked from Old-square to Cuckoo-road, Nechells, is a little over 2¼ miles in length. The length of single tramway track abandoned which would have had to be reconstructed appears to be about 2¾ miles. This was a single line with turnouts over parts, but about 1¾ miles of this single track consisted of a loop, the outward line on one street and the inward line on another parallel street. This long loop is equivalent for traffic purposes to a double line of half the length, but more expensive to construct than a double line in one street, and obviously much more expensive than a single line of half the length, with its turnouts.

Further, the tramway service was limited by the turnout positions to a minimum headway of five minutes. The trolley omnibuses running with a 4 minutes headway already take over 50 per cent. more in fares than the tramway did in the immediately preceding period. This shows that the tramway service was inadequate to the public needs. The tramway management was undoubtedly aware of that fact, and would presumably have estimated on improving the tramway when reconstructing it to permit of a more frequent service. The streets concerned are narrow and tortuous. It therefore seems probable that the unusually heavy amount of say, £80,000, or £28,000 per mile of single track—rather less if the turnouts are reckoned in—may have included a considerable amount for street widenings and other improvements.

Whether this is the explanation or not it seems obvious that for some special reason the reconstruction was estimated to cost five or six times the average pre-war cost of a town tramway track, including new concrete substructure, and it may be taken that this is not and will not be in future a general condition. It has to be observed that the estimates must have been made on the basis of material and labour costs in 1920 or 1921, and would no doubt be priced at considerably lower rates to-day. It may be hoped that there will be in the near future an even closer approximation to pre-war costs.

It will be understood that these remarks must not be taken as criticism of the estimates put forward by the Tramways Department; one cannot imagine that they were in any way weighted against tramway reconstruction. They are only made by way of caution against a hasty assumption that these costs are of general application.

The general case as between tramways and trolley omnibuses is well understood by everyone who has had to go into the question. The tramway involves greater capital expenditure, and therefore greater fixed capital charges. But its working expenses, including maintenance, are lower for equivalent carrying capacity. Since the fixed capital charges must be distributed over the car mileage to arrive at the total costs per car mile, it follows that at some traffic density,—which may be expressed at car miles per mile of route and per annum, or at some average frequency of service, or average headway,—the total costs per car mile are equal for the tramway and the trolley omnibus. For a greater traffic density the tramway, for a lesser traffic density the trolley omnibus, will be the more economical.

At pre-war rates it was generally estimated that this dividing line could be drawn at a headway of between ten and twenty minutes, varying with the circumstances of particular cases, and also it must be admitted with the individual estimator.

Post-war conditions have certainly increased capital costs and charges in a greater ratio than they have some of the working expenses, and it may therefore very well be that the economic range of the tramway is more limited than it was before. The carrying capacity of the trolley omnibus has also been increased as shown by those at Birmingham, which seat fifty-one passengers, and have roofed upper decks. The Birmingham omnibuses are also more roomy than the Birmingham tramcars, which suffer from the width restriction imposed by the 3ft. 6in. gauge. This improvement in capacity and comfort may be found to result in an improved ratio of working expenses to earnings, and certainly reduces the difference between the working expenses of tramcars and trolley omnibuses for equivalent carrying and earning capacities. Conceivably these may even be equalised, but it cannot be said that such equality is yet proved.

Assuming equal carrying capacity, similar conditions of traffic route, &c., there are certain differences which persist. Some of them can be valued already, some can only be priced by actual experience.

It may be assumed that the wages costs for driver and conductor will be equal, disregarding the fact that the steering of the omnibus calls for a certain skill in the driver not demanded by the tramcar.

The energy consumption of the omnibus is rather considerably greater than that of the equivalent tramcar. How much, and what this represents in money, will depend upon local conditions, but as the consumption difference is mainly due to the greater tractive effort required by rubber tires on road surfaces than by steel tires on steel rails it is a difference which will persist.

As regards maintenance, only experience will tell the full story. But there are certain considerations the trend of which can be indicated.

Tire maintenance on the omnibuses will be a rather heavy item. It appears that it will be in the neighbourhood of ¾d. per omnibus mile, which is not far from what was in pre-war days generally reckoned as the total repair and maintenance cost of the average tramcar. No doubt the tramcar figure is much greater now.

The omnibus motors will generally be smaller and of much higher speed for their rated power, and for equivalent carrying capacity of higher rating, for the omnibus than for the tramcar. This may be expected to result in a higher maintenance cost for brushes, commutators, and probably for the motors as a whole. One would expect a shorter economical life for the higher speed motors, but against that they should cost less per horse-power.

It is difficult to estimate the maintenance of the omnibus transmission gear. Worm gear is initially more expensive than the tramway gear wheel and pinion, it is less tolerant of inaccurate alignment, poor lubrication, and wear. It seems probable that this item will be heavier for the omnibus.

The trolley omnibus has steering gear, which the tramcar has not, and therefore a maintenance item against it.

Taking the tramway truck with its electrical and running gear against the omnibus chassis with its corresponding parts, and including as part of the power gear the single as against the double trolley, it appears that the locomotive part of the vehicle will be more costly in repairs and maintenance for the omnibus than for the tramcar.

As regards the body, there are several considerations which point to greater maintenance expenses and shorter economic life for the trolley omnibus. It is more important to save weight in the construction, and therefore the structure is likely to be less rigid than in the tramcar. The movements and stresses due to road irregularities will generally be greater and the racking effect upon joints, &c., more destructive. This is particularly the case with roofed, double-decked omnibuses. But very much depends upon the road surface. It is conceivable that on a well maintained smooth asphalt or wood block paving the resiliency of the tires and the springing may give no more shocks to the body than those received by a tramcar body. The perfect road surface can, however, hardly be postulated as a permanency, and the road maintenance will generally not be under the control of the omnibus authority.

Outside the vehicles, the cost of road maintenance is in favour of the trolley omnibus. This would not be the case if the tramway had only to maintain its own track, i.e., the rails, and if the trolley omnibus were charged with the whole cost of road maintenance. The tramway has under the present law to maintain the paving between and a margin outside its rails, which of course means that it bears a part—it may be the major part—of the whole road maintenance for all other traffic. The road maintenance cost charged to the trolley omnibus is a conventional figure, varying under different Acts and Orders, from ¼d. to ¾d. per omnibus mile. It does not appear that anyone has ascertained the true cost of the road damage done by these vehicles on different types of paving, and it is clearly a very difficult matter to investigate. The Birmingham undertaking should give an opportunity, if the Tramway and Highways Departments will co-operate for the purpose. It is clearly an item to be taken into account in making comparative estimates, and in municipal undertakings, where the ratepayers and the passengers are substantially the same persons, the true costs, as against the conventional or legal costs, are the true criterion.

As regards the overhead work, two wires have to be maintained for the omnibus against one for the tramcar; the maintenance should therefore be the greater for the former.

Summarising, therefore, it appears that the working and maintenance costs per car mile will be lower for the tramcar than for the trolley omnibus, but that only experience will prove whether this is the case, and the magnitude of the difference.

As regards capital costs, the principal items compare as follows:—

Track.—The tramway has to provide its own track, i.e., paving, rails and substructure. The life of rails is partly determined by the service. The life of the paving is determined by other traffic. The replacement charge is therefore only partly dependent on the service. The trolley omnibus has no capital expenditure or replacement charges upon its track.

Line Electrical Equipment.—The overhead line is more expensive for the trolley omnibus, because two conductors per track have to be provided. But the poles and other standing structure may be very little or not at all more costly to establish. Feeders may be more costly for the trolley omnibus if the length of line and traffic density necessitate the feeding of both conductors. This may resolve itself into a question of more capital for negative as well as positive feeders, or greater energy losses owing to voltage drop in the negative trolley. Some part of the greater energy consumption of the omnibus is in any case due to the double trolley losses. It may be important or not, according to circumstances. In extreme cases the double trolley losses may impose a greater number of feeding points. The item is against the omnibus.

Vehicles.—The capital cost of the trolley omnibus is greater than that of the equivalent capacity tramcar. It seems that this must always be the case, assuming the demand for both types of vehicle to warrant equal production economy in manufacture. The economic life of the trolley omnibus would appear to be decidedly shorter, so that a larger annual replacement charge is required.

There seems no reason for any material difference in the cost of shed and workshop equipment.

On the whole, then, it appears to be correct for post-war conditions, as it was for pre-war conditions, to say that the tramway demands greater capital expenditure and greater fixed annual capital charges than the trolley omnibus; but has lower working and maintenance costs. In some important respects the capital and maintenance costs for the tramway are artificially increased by legal provisions, and those of the trolley omnibus artificially reduced, though not in the same degree.

To some extent the change in conditions during the last nine years has narrowed the economic range of the tramway, partly by increasing capital costs and charges, partly by improvements in trolley omnibus design. The increase of capital costs and charges may not endure, or may not wholly endure. At any rate, it has been on the down grade for the last eighteen months. There are other items which cannot yet be evaluated, so that while the economic range of the tramway has been narrowed, it is premature to put a figure to it at present, or to indulge in generalities.

For any given case where a choice has to be made, it is imperative to consider all the factors, and to give the best value one can gather from available experience and intelligent forecast to the quantities which are not definitely known. This, after all, is only what every competent engineer or business man should do wherever he has to choose between alternative courses which will have far-reaching future consequences.

The incidence of rating has not been mentioned in the foregoing. The writer is not aware how trolley omnibus routes have been assessed to the rates heretofore, or that there have been any legal decisions on the question. It is an important item, especially with rates at their present value. It is quite impossible to guess what the Courts may decide if a decision is sought. Tramway authorities consider that they are too heavily assessed. It is hardly conceivable that trolley omnibuses will be more heavily assessed, but one cannot venture on any forecast.

RECONSTRUCTION WORK IN THE DEVASTATED REGIONS OF FRANCE.

THE progress made in the reconstruction of the devastated regions, and the cost of such reconstruction, have formed the subject of two articles in recent issues of the *Petit Parisien*. The total figures given for expenditure for reparation and reconstruction of buildings, purchase of materials, reorganisation of public services, &c., show that 54,050,000,000f. had been incurred up to December 31st, 1922. Expenditure amounting to about 800,000,000f. for reconstruction work in Alsace and Lorraine is not included in the figure, such expenditure not being recoverable under the Peace Treaty; neither does the figure of fifty-four milliards odd include the sum of 8,800,000,000f., the amount of interest paid on loans which have been issued by France in order that money might immediately be forthcoming for the work of reconstruction.

A pamphlet entitled "France at Work to Repair Her War Damages," published by the Ministry of Devastated Regions, shows that, at the end of the war, 741,993 houses had been either totally destroyed or badly damaged. At the end of January, 1921, 278,834 had been rebuilt or repaired; one year later that number had increased to 355,479, and on January 1st, 1923, 553,977 had been rebuilt and rendered habitable, thus enabling the population of the devastated regions to return to their former homes. Of 4,690,183 persons living in the devastated regions before the war, 3,288,152 had returned in January, 1921, 3,985,913 had returned the next year, and on January 1st, 1923, the total amounted to 4,074,970, or getting on towards the whole of the pre-war population.

The work of rendering the war-torn ground fertile once more is being courageously carried forward. When the Armistice was concluded 3,306,350 hectares of ground, including 1,023,479 hectares of what were once ploughed fields, were judged to be incapable of cultivation. Now, however, 1,698,200 hectares are once more under cultivation. To arrive at this result it was necessary to fill in 280,102,300 cubic metres of trenches, to clear away 287,200,815 square metres of barbed wire, and to destroy 1,035,200 shells which had been either abandoned or buried in the ground. More than half the live stock which existed in the devastated regions before the war has now been replaced.

From an industrial point of view, the progress made has been excellent. Of 22,900 factories which were destroyed or badly damaged, 19,967 had been reconstructed at the beginning of the year. Of 58,697 kiloms. of roadways which had been destroyed, 32,650 kiloms. had been reconstructed by January 1st, 1923. It is said, indeed, that those who only saw the battlefields in their devastated condition now have difficulty in recognising spots which they knew well, so much has the surface of the country changed since 1918.

BOOKS RECEIVED.

One Thousand Questions and Answers on Company Law. By Henry A. Ashton. London: The London Financial Service, Limited, 69, Fleet-street, E.C. 4. Price 5s. net.

Mercury Ores. By Edward Halse. Imperial Institute Monographs on Mineral Resources, with special reference to the British Empire. London: John Murray, Albemarle-street, W. 1. Price 5s. net.

Milling Machine for Copper Fire-box Plates.

THE vertical spindle milling machine, illustrated herewith, has been recently designed and constructed by Alfred Herbert, Limited, of Coventry, for Elliott's Metal Company, Limited, Selly Oak Works, near Birmingham, its purpose being the milling of locomotive or other copper fire-box plates. The machine has several features peculiar to it by virtue of the size and shape and the nature of the material operated upon—such, for example, as the long overhang of the spindle, provided to permit the cutter to reach the centre of large plates, the low height

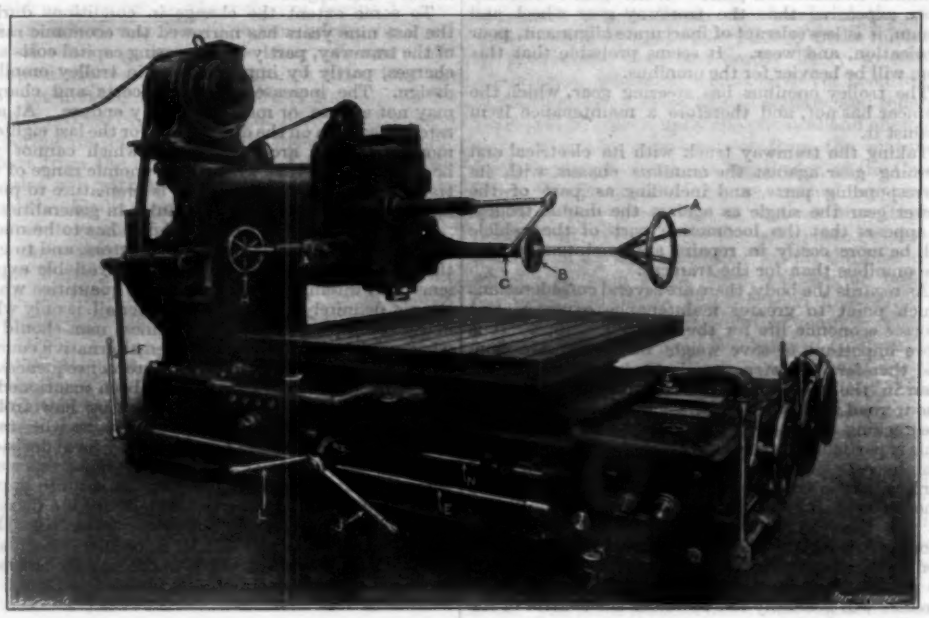


FIG. 1—MILLING MACHINE FOR FIREBOX PLATES

of the spindle nose above the table, and the small range of hand adjustment in this direction, features incorporated by reason of the limited thickness vertically of the work operated upon, and the absence of low spindle speed and of any means of supplying cutting lubricant to the work, omissions made possible by reason of the fact that copper can most suitably be cut dry and at high speeds. Apart, however, from these particular features, the machine embodies others of quite general interest to machine tool designers.

The machine is of the single pulley type, and is preferably driven by a motor mounted—as shown in the engravings—on top of the column. In the instance illustrated the motor is of the constant speed, non-reversing type, developing 20 horse-power, and is fixed on a hinged base plate which, by means of an adjusting screw, may be raised at one end for the purpose of tightening the main driving belt. A starting switch is carried on the left hand side of the column, but when the machine is in use the practice followed is to allow the motor to run continuously and to start and stop the spindle and feed motions by way of a friction clutch interposed in the drive.

Regarded generally, the machine may be described as consisting of the following main parts:—The bed, the overhanging column fixed to the bed and carrying the adjustable spindle head at the front end, a driving box attached to the rear of the column through which power at various speeds is transmitted to the spindle, a lower saddle, an intermediate slide, and an upper table whereby the work may be adjusted or fed transversely, longitudinally or circularly, and an apron fixed to the front vertical face of the bed and containing or carrying gearing and controls, whereby hand power or power derived from a feed-box may be applied to cause the top table to move in either of the three ways for feeding or traversing purposes.

The bed towards the front is formed with guiding surfaces whereon the lower saddle slides transversely—that is to say, in the direction from the apron towards the column—and towards the rear with a plain face to which the column is bolted. The column is very stiffly constructed in order to give the requisite rigidity at the long overhang. On its front face it is formed with vertical guides for the spindle head. The latter is balanced by an attached weight inside the column and can be raised or lowered through a range of 9in. by means of the hand wheel A, Fig. 1. On the shaft of this wheel a graduated disc B is provided to permit the head to be adjusted to a definite position. A lever C operates a taper gib extending the full length of the slide which locks the spindle head in its adjusted position.

The spindle runs in adjustable white metal bearings, and its weight, together with that of the attached gear wheels and of the cutter, is taken on a large ball thrust bearing. Large cutters are mounted on the external taper at the spindle nose, and are secured with a drawbolt. Smaller cutters, arbors, &c., are held in a tapered bore in the nose. The drive to the spindle is made by way of the driving box attached to the rear of the column. The pulley driven by the motor runs on ball bearings, and is supported on a fixed sleeve in such a way that the driving shaft is relieved of all pull from the main belt. A friction clutch of the expanding ring type serves to connect the shaft to the pulley, the handle operating this clutch being situated at the front of the machine—see D, Fig. 2. This handle is attached to a shaft running within the apron and connected by mitres to a shaft E, Fig. 1, extending to the rear of the machine. An auxiliary starting handle is provided at F, and a corresponding one G on the opposite side of the bed, the purpose of these handles being for momentarily starting the driving mechanism if when the spindle speed is being changed the gear teeth do not immediately slide into engagement. As indicated in the general arrangement drawing—Fig. 3—the driving box provides four changes of spindle speed by means of sliding gear wheels, which are operated by two interlocking hand levers moving in front of a speed index plate. From the horizontal shaft driven by these gear wheels, power is transmitted through mitres to a vertical shaft lying just behind the spindle head and equipped with a very wide gear wheel, from which the spindle is driven by a pair of sliding wheels. The engagement of the sliding pair is controlled from the hand wheel H—Fig. 1—the width of the first gear wheel being sufficient to accommodate not only the shift required for the engagement, but also the height adjustment of the spindle head as a whole. The eight spindle speeds thus provided range from 100 to 350 revolutions per minute, with the motor running at 750. The main driving pulley, it is to be noticed, is surrounded by a belt guard extending to a height of 6ft. above the floor, while the belt and pulleys driving the feed and power traverse shafts are also completely enclosed within a guard. The whole of the main transmission gearing is made of heat-treated chrome nickel steel, and all the shafts connected with it run in ball bearings.

The saddle or lower table is guided on the bed by means of a narrow raised central surface, the length of which, compared with its width, is sufficient to maintain the saddle in square relationship with the bed. Tapered gibs are provided at the outer edges of the saddle to hold it down. These gibs can be moved endwise to clamp the saddle by means of the handles J J—Figs. 1 and 2. On its upper surface the saddle is formed with longitudinal guides of large area for the intermediate slide, which in turn carries a circular guide for the top table. The intermediate slide—as will be best seen from Fig. 3—overhangs the saddle to a considerable extent at the front end, with the result that the centre of the top table is proportionately offset relatively to the centre of the saddle. The object of this arrangement is to secure the greatest possible amount of support under the back half of the table, where all the cutting takes place, without making the saddle of excessive width. The top table, though rotary, is square in plan. It can be clamped in position by means of either of the handles L L—Figs. 1 and 2.

The feed box, whereby the feed changes for the three motions of the table are obtained, is situated on the right-hand side of the bed at M—Fig. 2. Power for the feed is obtained by way of a vee-belt from a pulley attached to the end of the main driving shaft—see Fig. 3. The lower pulley drives a constant-speed shaft which, passing through the feed-box, is continued to the apron at the front of the bed, and is there connected to the gearing operating the quick power traversing motions of the table. A variable speed shaft extends from the feed-box to the apron below the constant speed shaft, and operates the feed gearing. The two shafts are enclosed within protecting cast iron guards, and are supported at the mid point of their lengths in a bracket bolted to the bed.

The apron at the front of the bed is shown in Fig. 4, and carries all the hand wheels and levers necessary for the control of the power and hand feeds and quick traverses of the table. Towards the right a lever is provided whereby the power feed motions may be reversed in direction. The remaining controls consist of three similar groups of items, each group comprising one hand wheel for the hand feed, and two levers for the application of the corresponding power feed and quick power traverse. In order, from left to right, the groups control the transverse, longitudinal and rotary motions of the table. The three feed levers—B_1, B_2 and B_3—engage the respective feeds by means of dropping worms, which may be tripped either by the levers or automatically by stops on the saddle, slide, or table, as the case may be. Transverse feed motion is applied to the saddle by a long nut on its underside engaging with a screw, the thrust of which is taken on ball bearings. The stops for this motion are situated on the shaft N—Fig. 1. The longitudinal feed is communicated to the intermediate slide through a shaft running transversely down the cavity in the bed which drives by mitre gearing a long rotating nut engaging with a stationary screw extending beneath and attached to the intermediate slide. The automatic stops for this motion are adjustable in a tee-slot at the back of the slide. The rotary feed to the table is transmitted from the apron by way of a shaft passing down the right-hand side of the bed into a box attached to the front of the saddle, which box contains mitres driving a longitudinal shaft. The latter shaft drives, through worm gearing, the main worm shaft, from which power is communicated to a large worm wheel bolted to the underside of the table. The automatic stops for the rotary motion are carried in a circular tee-slot provided on the underside of the table.

The quick power traversing motions are controlled through friction clutch mechanism by the levers C_1 C_2 and C_3—Fig. 4. These levers are so arranged that they are movable in the direction in which it is desired to traverse the table, the movement of the handle C_3 corresponding in direction with that in which the front edge of the table moves when it is rotated. The three handles control the traverses in either direction independently of the position of the lever employed for reversing the feed motions, although the feed and traversing motions are interlocked in such a way as to prevent their being engaged at the same time. The power traverses for the saddle and intermediate slide are affected at a rate of 100in. per minute.

The feed changes number nine and range from 2in. to 20in. per minute. They are obtained from the feed-box by means of Messrs. Herbert's patented dial motion.

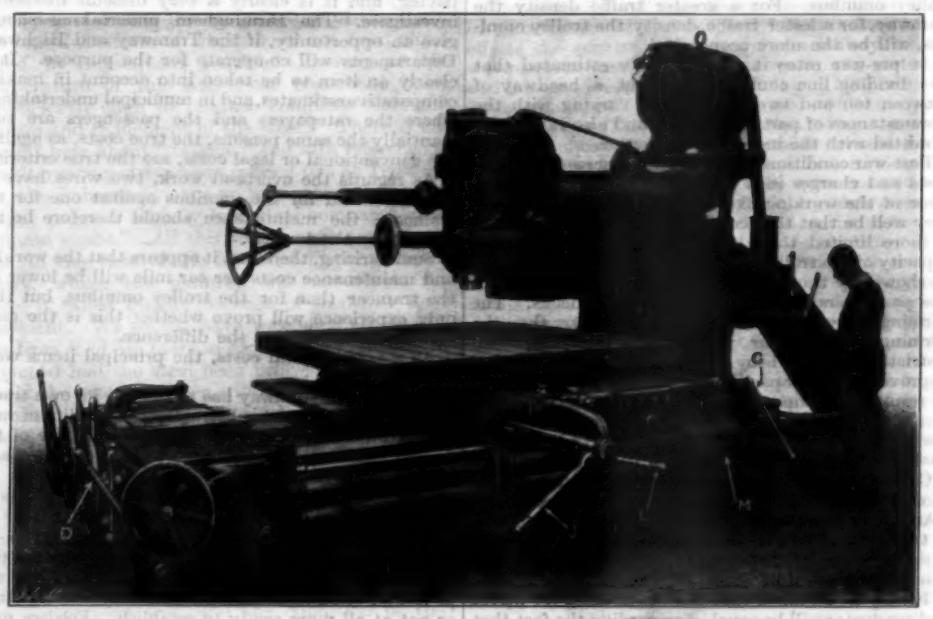


FIG. 2—FEED BOX SIDE OF MILLING MACHINE

operated by a cam and levers inside the box. The hand wheel by which the cam is rotated and the dial showing the rates of feed, are mounted on an angular shaft at the right-hand end of the apron, the whole range of feeds being obtainable by simply rotating the hand wheel.

All the spur and bevel gearing of the feed and quick power traverse drives is of heat-treated chrome nickel steel, the worms are of case-hardened steel, and the worm wheels of phosphor bronze, except in the case of the large wheel bolted to the underside of the table, which wheel is of cast iron. Ball bearings and ball thrust bearings are used extensively throughout the mechanism, particularly in connection with the high-speed shafts transmitting the power traversing motions.

Attached to the underside of the intermediate slide and

MILLING MACHINE FOR COPPER FIREBOX PLATES

ALFRED HERBERT, LIMITED, COVENTRY, ENGINEERS

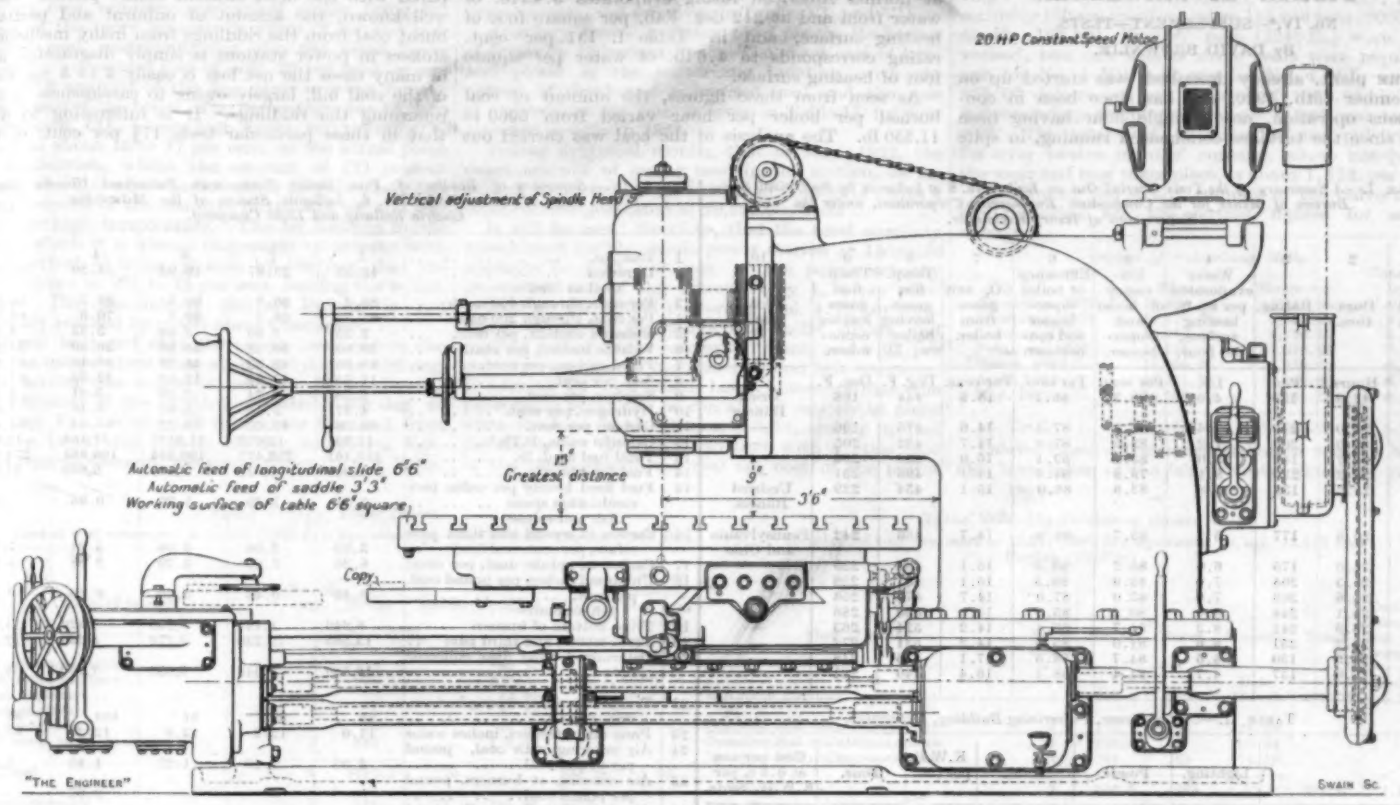


FIG. 3

projecting towards the operator is a small platform provided for the reception of a wooden or other templet or copy when it is required to mill curved faces on the work. The templet works in conjunction with a roller, supported by a bracket on a compound slide on top of the apron. The roller used must have the same diameter as the milling cutter, and is adjusted to the same position relatively to the templet as the cutter bears the work. No provision is made, as, for instance, by means of a weight, for keeping the roller automatically in contact with the templet, so that the arrangement is not a regular profiling attachment. It is intended merely to facilitate curvilinear milling by the manipulation of the hand feeds, or of a combination of a hand and a power feed in such a way as will cause the roller just to maintain contact with the templet. Without it, the length of the bed would prevent the operator from keeping the cutter itself under very close observation. The roller can be reversed from the position shown in the engravings, that is to say, it can be mounted with its boss downwards. In this condition the roller lies above the plane of the templet and just clear of it. The feeds may then be manipulated without fear of causing a jamb between the roller and the templet.

The lubrication of the mechanism of the machine has been made a subject of special attention. In the case of some of the slow moving and less accessible shafts, such as those supporting the balance weight pulleys, oil-less bushings are provided, but elsewhere the main units are lubricated automatically. A reservoir is provided in the spindle head for the lubrication of the spindle and its associated gear wheels. Oiling rollers and baths are employed for lubricating the surfaces of the saddle, intermediate slide and table. In the feed-box a small force pump is arranged by which oil is elevated into a reservoir above the driving box. Passing through a sight-feed indicator the oil cascades over the gear wheels, shafts and bearings in the driving box and escapes into a second reservoir in the upper surface of the bed inside the column. It then descends into a third reservoir in the feed-box, lubricating on its way in a similar manner the mechanism of that box. A force pump similar to that in the feed-box is contained in the apron. It pumps oil from a reservoir at the bottom of the apron to a perforated tray at the top, whence the oil descends over the gear wheels, bearings and other parts of the apron mechanism.

The machine has a total net weight of about 18 tons and occupies a floor space measuring 17ft. 6in. square.

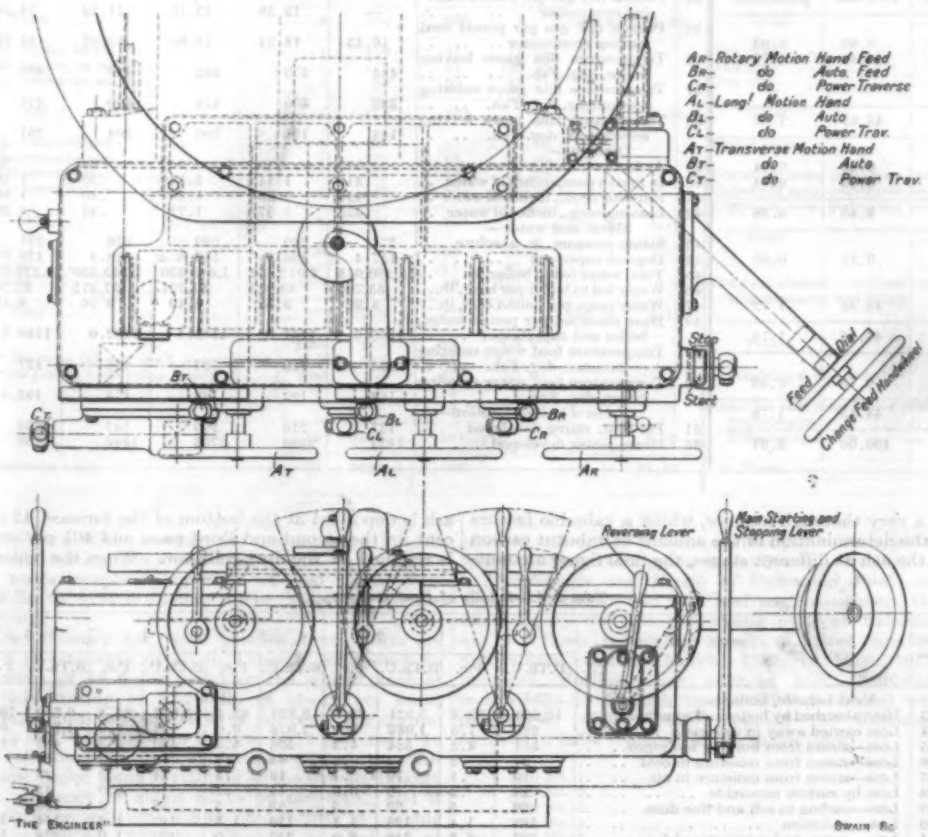


FIG. 4—DETAILS OF APRON

American Engineering News.

(From our own Correspondent.)

LAYING TRAM RAILS 420 FEET LONG.

OWING to the time required for renewing rails on an electric conduit line, where they have to be adjusted on the cast iron yokes and bolted in place, the plan of welding up the new rails in long stretches has been employed on the Washington Electric Railway, of Washington, U.S.A. Grooved girder rails, 6in. high and of 120 lb. per yard were used, rolled in 60ft. lengths. With seven rails welded together they made single sections of 420ft. in length. The joints were welded by the thermit process, the rails being laid at the side of the street and clamped between heavy rolled steel joists to hold them in line. Gangs of twenty-five men with rail tongs and crow-bars moved the 420ft. lengths gradually across to the tramway, where they were placed on pipe rollers and hauled to their positions. Then twenty-eight men with seven four-man rail tongs shifted the rail on to the yokes as soon as the old rails were removed and the rail seats cleaned. Temporarily they were bolted only to every fifth yoke, or at intervals of 25ft. Later, during the day, they were adjusted to exact level by wedge plates and finally bolted. If the time did not allow of welding the end of the 420ft. rail in place, it was bolted up temporarily. In this way the heavy work was done during a 3½-hour night shift, when the occasional cars could be handled on one line of rails.

WELDED JOINTS FOR STEEL STRUCTURES.

CONSIDERABLE progress is being made in the United States with the construction of steel-frame structures having the joints electrically welded instead of put together with rivets or pins. These applications of electric welding include foot bridges, roof trusses, buildings and brackets welded to workshop columns to support crane runways. Although the strength of riveted joints depends upon their shearing value, tests of welded joints have been made usually in tension on members put together with butt joints. Recent shearing tests have been made, however, upon plate joints made by welding on splice plates. These tests showed an average strength of 36,300 lb. in shear. In a welded truss of 56½ft. span there was considerable saving of material in the joints and also in the tension members, the latter being due to the absence of rivet holes which reduce the cross-sectional area. The bottom boom, for instance, was made up of two angles 2½in. by 2½in. and $^{7}/_{16}$in. thick, with a gross and net section of 4 square inches. But in a corresponding riveted truss this boom would be made up of two angles 3in. by 3in. and $^{7}/_{16}$in. thick, giving a gross area of 4.86 square inch and a net area of 3.99 square inch. The saving of weight in this way alone was 304 lb. The saving in cost cannot be determined, as there has not been sufficient experience to give accurate records of cost in the electric welding of structures of this kind.

The Lakeside Electric Power Station at Milwaukee.

No. IV.*—SUPPLEMENT—TESTS.

By DAVID BROWNLIE.

The plant, already described, was started up on December 15th, 1920, and has since been in continuous operation, not a single hour having been lost since the turbines commenced running, in spite of the fact that the new staff were not experienced in working with pulverised fuel, and only minor alterations have been required, whilst the results obtained have exceeded expectations, even with the use of low grade "Illinois" coal of 11,000 B.Th.U., such as is not generally used for mechanical stokers. A most elaborate series of tests has been carried out on this plant, probably unsurpassed in the world for care and accuracy and for the time and trouble taken, together with the fact that they represent genuine running conditions from week to week of the plant all the year round.

The detailed results of five typical tests at different duties and of 19.92–42.33 hours' duration, are given in Table IV., whilst the condensed figures of fifteen other tests are given in other tables.

Considerable confusion is caused in this country by the unscientific American method of using the term "boiler horse-power." The American boiler horse-power means an evaporation of 34½ lb. of water from and at 212 deg. Fah. per square foot of heating surface of the boiler, and this arbitrary figure was adopted in 1876 at the Centennial Exhibition at Philadelphia, because at that time the average steam engine took 34½ lb. steam per indicated horse-power. Consequently, a "boiler horse-power" is an evaporation of enough steam per square foot of heating surface to give 1 horse-power in the average American steam engine of 1876, that is, 34½ lb. water. A boiler under American standards is allowed 10 square feet of heating surface per horse-power, so that a boiler at normal American rating evaporates 3.45 lb. of water from and at 212 deg. Fah. per square foot of heating surface, and in Table I. 137 per cent. rating corresponds to 4.6 lb. of water per square foot of heating surface.

As seen from these figures, the amount of coal burned per boiler per hour varied from 5960 to 11,350 lb. The analysis of the coal was carried out in a very thorough manner, whilst a valuable feature is the determination of the amount of unburnt carbon in the ash at different stages, the final figure amounting to 0.40 to 0.74 per cent. unburned carbon on the weight of the coal, thus confirming the general figure given of less than 1 per cent. It is very difficult to get authentic figures for the corresponding mechanical stoker performance; but certainly pulverised fuel has the advantage in this respect, even when compared with the most efficient stoker plants. As is well known, the amount of unburnt and partially burnt coal from the riddlings from many mechanical stokers in power stations is simply disgraceful, and in many cases the net loss is easily 4 to 5 per cent. of the coal bill, largely owing to carelessness in not reburning the riddlings. It is interesting to note that in these particular tests 17½ per cent. of the ash is deposited at the bottom of the furnace, 42 per cent. in the second and third pass, and 40½ per cent. is retained in the dust collector. When the boiler is forced, as in Test 5, Table IV., it will be noted that the amount in the dust collector increases rapidly.

The actual amount of excess air used to burn

* No. III. appeared April 27th.

Table I.—*A Summary of the Tests Carried Out on Boiler No. 8 at Lakeside by the United States Bureau of Mines for the Combustion Engineering Corporation, under the Supervision of Henry Kreisinger.*

1 Test No.	2 Duration.	3 Rating.	4 Water evaporated per sq. ft. heating surface per hour.	5 Efficiency of boiler and superheater.	6 Efficiency of boiler superheater and economiser.	7 CO_2 exit gases from boiler.	8 Temp. flue gases leaving boiler.	9 Temp. flue gases leaving economiser.	10 Coal used.
	Hours.	P.c.	Lb.	Per cent.	Per cent.	Per cent.	Deg. F.	Deg. F.	
1	42.3	137	4.6	83.3	86.3	15.8	434	168	Dried Illinois
2	24.0	215	7.4	82.6	87.1	14.6	475	196	—
3	20.0	209	7.2	82.5	87.0	14.7	482	205	—
4	24.7	146	5.0	85.4	89.1	16.0	430	204	—
5	24.2	236	8.1	79.8	84.6	14.1	496	251	—
6	28.2	129	4.8	83.8	88.0	15.1	454	229	Undried Illinois.
7	25.6	177	6.1	83.7	88.0	14.7	466	242	Pennsylvania and Ohio
8	24.0	175	6.0	85.2	89.6	15.1	468	239	—
9	24.3	204	7.0	83.9	88.3	15.1	487	256	—
10	24.6	203	7.0	83.0	87.0	14.7	474	256	—
11	24.1	244	8.4	80.2	85.0	14.0	530	286	—
12	23.9	241	8.3	81.7	86.4	14.2	524	263	—
13	24.2	251	8.6	81.0	85.6	14.2	531	272	—
14	24.5	130	4.5	84.7	88.5	17.1	435	218	—
15	17.6	137	4.7	84.4	88.4	16.4	440	221	—

Table II.—*Cost of Power, Pulverising Building, Milwaukee.*

	Lighting.	Power.	Total.	K.W.H. per ton.	Tons.	Cost per ton at 0.5 c. per K.W.H., cents.
February	13,220	314,470	327,690	23.2	14,118	11.60
March	14,324	366,376	380,700	23.7	15,996	11.85
April	13,192	377,667	391,579	25.5	15,311	12.25
May	8,114	370,584	378,798	24.0	15,707	12.00

Table III.—*Lakeside Station, Milwaukee.—Total Actual Electric Energy Used in Station as Recorded by Meters, May, 1922.*
Output of station = 20,299,000 K.W.H. generated (gross).

	440 volt.	250 volt.	Total.	Per cent. of turbine-room use.	Per cent. of total station use.	Per cent. of total K.W.H. generated.
Turbine-room—						
Turbine-room lighting	5,933	979	6,912	1.87	0.86	0.03
Turbine-room auxiliaries	361,440	—	361,440	98.13	44.81	1.78
Emergency exciter No. 1	—	2	2	—	—	—
Emergency exciter No. 2	—	—	—	—	—	—
Total turbine-room power	367,373	981	368,354	100.00	45.67	1.81
Boiler-house—						
Boiler-house lighting	5,934	489	6,423	8.43	0.80	0.04
Boiler-house auxiliaries	69,760	—	69,760	91.57	8.65	0.34
Total boiler-room power	75,694	489	76,183	100.00	9.45	0.38
Pulveriser building—						
Pulveriser building lighting	5,933	629	6,562	1.84	0.81	0.03
Pulveriser mills, driers, pumps, screw conveyer, drier feed motors	344,380	5207	349,587	98.16	43.34	1.72
Total pulveriser building	350,313	5836	356,149	100.00	44.15	1.75
Shaker hammer mill crusher, 48in., belt, inclined belt	5,670	228	5,898	—	0.73	0.03
Total pulverised coal			342,047		44.88	1.78
Station total	799,050	7534	806,584		100.00	3.97

Table IV.—*Summary of Results of Five Boiler Tests with Pulverised Illinois Coal.—Tests Made on Boiler No. 8, Lakeside Station of the Milwaukee Electric Railway and Light Company.*

		1	2	3	4	5
1	Test No.					
2	Duration	42.33	23.97	19.92	24.20	24.17
	Coal as fired—					
3	Per cent. through 100 mesh	89.2	90.8	90.5	92.2	90.5
4	Per cent. through 200 mesh	67.7	68.7	69.1	70.5	66.7
5	Moisture content, per cent.	2.25	3.56	3.59	5.24	5.61
6	Volatile matter, per cent.	36.60	36.48	35.66	36.30	35.25
7	Fixed carbon, per cent.	40.60	48.33	48.70	46.10	47.16
8	Ash, per cent.	11.55	11.63	12.05	12.36	11.38
9	Sulphur, per cent.	2.26	2.74	2.28	3.91	3.39
10	Hydrogen, per cent.	4.97	5.18	5.01	5.10	5.06
11	Carbon, per cent.	68.88	67.20	66.22	63.44	65.41
12	Calorific value, B.Th.U.	12,321	12,022	11,917	11,488	11,661
13	Total fuel fired, lb.	253,161	233,477	190,334	160,881	274,640
14	Fuel fired hourly, lb.	5,960	9,740	9,560	6,650	11,350
15	Fuel fired hourly per cubic foot combustion space	0.85	1.39	1.36	0.95	1.62
	Ash and refuse—					
16	Carbon in second and third pass refuse, per cent. coal fired	3.60	5.06	5.06	5.31	7.17
17	Carbon in uptake dust, per cent.	6.26	5.09	3.39	2.82	5.95
18	Unburned carbon per pound coal, per cent.	0.45	0.45	0.40	0.40	0.74
	Ash account—					
19	From bottom of furnace	6,240	6,141	5,230	4,420	1,000
20	From second and third pass	13,565	12,236	9,278	8,260	12,270
21	Determined from dust collector data	10,580	8,640	8,632	7,290	18,120
	Air—					
22	Temperature air entering furnace, deg. Fah.	86	89	91	104	93
23	Press air of feeders, inches water	11.0	12.2	13.6	12.2	13.6
24	Air entering with coal, pound per pound coal	2.05	1.25	1.27	1.85	1.03
25	Air entering at burners, pound per pound coal	—	—	—	2.07	—
26	Air through hollow wall, pound per pound coal	—	—	—	5.64	—
27	Excess air in flue gases, per cent.	13.3	21.9	21.2	10.7	25.2
	Flue gas—					
28	Carbon dioxide in fourth pass, per cent.	15.8	14.6	14.7	16.0	14.1
29	Oxygen in fourth pass, per cent.	3.3	4.6	4.6	3.3	5.2
30	Carbon monoxide, fourth pass, per cent.	0.05	0.0	0.03	0.0	0.09
31	Carbon dioxide entering econ.	—	12.6	12.8	14.4	11.5
32	Carbon dioxide leaving econ.	10.4	11.9	12.0	13.2	10.8
33	Pounds dry gas per pound coal leaving boiler	11.04	11.63	11.37	10.06	11.56
34	Pounds dry gas per pound entering economiser	—	13.36	13.16	11.14	14.10
35	Pounds dry gas per pound coal leaving economiser	16.45	14.11	13.80	12.07	15.01
36	Temperature flue gases leaving boiler, deg. Fah.	434	475	482	430	496
37	Temperature flue gases entering economiser, deg. Fah.	338	400	424	400	431
38	Temperature flue gases leaving economiser, deg. Fah.	168	196	205	204	251
	Draught—					
39	At furnace, inches of water	.017	.19	.16	.045	.206
40	In fourth pass, inches of water	.314	1.11	1.185	.39	1.40
41	Entering econ., inches of water	.424	1.23	1.28	.40	1.66
42	Leaving econ., inches of water	.525	1.67	1.72	.51	2.38
	Steam and water—					
43	Steam pressure, lb. absolute	276	280	280	276	281
44	Degrees superheat	137.4	180.8	186.8	118.4	178.6
45	Total water fed to boiler, lb.	2,260,018	2,012,452	1,615,530	1,393,250	2,228,514
46	Water fed to boiler per hour, lb.	53,390	83,953	81,121	57,572	92,202
47	Water evap. per pound coal, lb.	8.92	8.62	8.49	8.66	8.12
48	Heat absorbed per pound water, boiler and superheater	1149.6	1151.0	1158.4	1132.0	1146.6
49	Temperature feed water entering economiser, deg. Fah.	126	129	124	126	127
50	Temperature feed water entering boiler, deg. Fah.	168	192	188	175	195.4
	Rates of heat absorption—					
51	Per cent. rating developed	137	215	209	147	236
52	Horse-power developed	1833	2886	2798	1946	3156

Table V.—*Details of Heat Balances.*

Test No.		1		2		3		4		5	
		B.Th.U.	P.c.	B.Th.U.	P.c.	B.Th.U.	P.c.	B.Th.U.	P.c.	B.Th.U.	P.c.
	Heat balance, boiler—										
53	Heat absorbed by boiler and superheater	10,200	83.3	9,924	82.6	9,835	82.5	9,803	85.4	9,309	79.8
54	Loss carried away in dry gases	928	7.5	1,086	9.0	1,076	9.0	794	6.9	1,130	9.7
55	Loss—steam from burning hydrogen	511	4.2	524	4.3	506	4.3	480	4.2	488	4.2
56	Loss—steam from moisture in coal	27	.2	43	.4	44	.4	62	.5	69	.6
57	Loss—steam from moisture in air	10	.1	10	.1	13	.1	21	.2	23	.2
58	Loss by carbon monoxide	22	.2	0	0.0	14	.1	0	0.0	42	.4
59	Loss—carbon in ash and flue dust	66	.5	62	.5	59	.5	59	.5	108	.9
60	Loss—radiation	166	1.4	125	1.1	125	1.1	147	1.3	114	1.0
61	Loss—errors and unaccounted for	331	2.6	248	2.0	245	2.0	125	1.0	378	3.2
62	Total	12,321	100.0	12,022	100.0	11,917	100.0	11,491	100.0	11,661	100.0
	Heat balance, economiser—										
63	Total heat supplied, items 54/57	1,476	12.0	1,663	13.8	1,639	13.8	1,357	11.8	1,710	14.7
64	Heat absorbed by economiser	375	3.0	543	4.5	543	4.5	432	3.8	556	4.8
65	Loss—dry gases delivered from boilar	219	1.8	301	2.6	314	2.6	244	2.1	444	3.8
66	Loss—air leaking into economiser	107	.9	63	.5	67	.6	49	.4	132	1.1
67	Loss—water vapour	483	3.9	506	4.2	491	4.1	493	4.3	505	4.3
68	Total heat accounted for	1,184	9.6	1,413	11.8	1,415	11.8	1,218	10.5	1,637	14.0
69	Radiation and unaccounted for	292	2.4	250	2.0	224	2.0	139	1.2	73	0.7
70	Heat absorbed by boiler and economiser	10,635	86.3	10,467	87.1	10,378	87.0	10,235	89.1	9,685	84.6

the coal was determined with great care, and the figures were found to vary from 10.7 to 25.2 per cent. excess, rising as the plant was forced, but showing, of course, a perceptible advantage in this respect over ordinary mechanical stoker firing because of the more intimate mixture of air and pulverised coal, and confirming also the usual figure given for pulverised fuel of only 20 per cent. excess air. The analysis of the flue gases is given for the fourth pass of the boiler. The percentage was 14.1 to 16 per cent. CO_2, a very high figure, and presumably equal to about 16 to 17 per cent. at the actual point of combustion, whilst the amount of CO present is nil, which is also characteristic of pulverised fuel firing because of the intimate mixture of air and fuel and the high temperature. The air leakage in the plant, which it is almost impossible to prevent with any method of firing, is seen by the fact that the CO_2 is down to 10½ to 13 per cent. leaving the economiser. The amount of this air leakage is not generally realised by power station engineers.

It will be noted that the economisers reduce the flue gas temperature from about 430 deg. to 496 deg. Fah. leaving the boiler—a very low figure showing the efficiency of the working—to about 168 deg. to 251 deg. Fah., whilst the feed-water is raised from 124 deg. to 127 deg. Fah. to 168 deg. to 195 deg. Fah.

As regards draught, the figure varies from 0.525in. to 2.38in. W.G. leaving the economiser, but at normal running it is about 1½in. to 2in. W.G., whilst the water evaporated per lb. of coal varies from 8.12 lb. to 8.92 lb., being about 8½ lb. for normal working.

The efficiency and heat balance-sheet figures are given in elaborate detail in Table V., and show an efficiency of 84.6 per cent. for the whole plant at the high rating of 92,200 lb. of steam per hour, corresponding to about 85 to 86 per cent. for normal rating and varying from 84.6 to 89.1 per cent. In general, therefore, it may be stated that the Milwaukee boiler plant is running at the extraordinarily high efficiency of about 85 to 86 per cent., and it is fully expected there will be no difficulty in running the completed 200,000-kilowatt installation at 88.15 per cent. boiler plant—boilers, superheaters and economisers—efficiency, even with the poor quality Illinois coal.

A point of great interest to British engineers is the cost of preparing the fuel, the power required by the pulverisers, conveyors and dryers, and the amount of labour, together with the wear and tear and cost of upkeep. It is generally admitted that pulverised fuel firing is extremely efficient if only because of the fact that only about 20 per cent. excess air is required, as compared with, say, 35 per cent. for efficient stoker practice; but on the above points of cost of preparation we have long been in need of authentic data. The Milwaukee figures are particularly valuable in this connection, representing many months of careful observation and investigation, and are given in Tables VI. and VII.

Auxiliary Steam or Power Used for the Production of Steam by Pulverised Fuel.—The exact cost of light and power in the pulverising building, with the output of dried and pulverised coal and the cost of pulverising per ton, is given in Table II. for four separate months in 1922.

Taking a typical month, that of May, 1922, the exact amount of power used in the station, as recorded by meters, is as shown in Table III., with a total current generated of 20,299,000 units:—

It will be seen, therefore, that the total auxiliary power used for the whole power station at Lakeside amounts to 3.97 per cent. of the power actually generated, and of this amount only 1.75 per cent is used for the actual pulverised fuel, 1.72 per cent. being taken by the pulverising mills, dryers and motors, including the conveying plant, and 0.03 per cent. for the shaker, hammer-mill and belt conveyor. It should be mentioned here, however, that the pulverising plant can be run almost entirely at night when the load on the station is light, storing up fuel for the heavy day loads, so that with a little care in the management the real net cost of the power and during this period 115,630 tons (2000 lb.) equals 103,240 English tons (2240 lb.) were pulverised, corresponding therefore to 0.39d. per ton for new rings. Finally also from March, 1921, to May, 1922, inclusive (fifteen months), when 183,046 tons (2000 lb.) equals 163,430 English tons (2240 lb.) were pulverised, two new sets of drive gears were required, one for No. 1 Mill and one for No. 4 Mill, costing 651.00 dollars per set, a total of 1302.00 dollars, corresponding therefore to about 0.38d. per ton of coal. The total cost, therefore, of the pulverisers for over twelve months' running, where nearly all the wear and tear takes place, is about 1.17d. per ton.

As showing the steady running of the pulverisers, the following are the output figures for seven months:—

Output of Pulverising Mills.

	Tons.	Hours run.	Tons per hour.
November, 1921 ..	13,564.55	3,213.25	4.22
December, 1921 ..	11,576.90	2,499.92	4.63
January, 1922 ..	14,910.50	2,776.50	5.36
February, 1922 ..	14,118.25	2,016.25	7.00
March, 1922	15,905.66	2,239.50	7.14
April, 1922	15,311.19	2,419.25	6.33
May, 1922	15,706.50	2,481.25	6.33
Total	101,183.55	17,645.92	5.73

Labour Costs.—The most elaborate records have also been taken of the labour costs, which are given in Tables VI. and VII. for a typical month (April, 1922) for the complete boiler installation, divided into (*A*) boiler-house, and (*B*) pulveriser-house.

The total staff, therefore, in the boiler-house is 63 men at a total wage of 4260.44 dollars, equals, say, £852 per month, corresponding to a total cost of 27.63 cents per American (2000 lb.) ton, or 15d. per English ton (2240 lb.) on the basis of American wages.

The total staff, therefore, for the complete boiler-house, boiler and pulverising, &c., plant, together, is 86 men at a total wage of 7140.50 dollars, equals, say, £1428.1 per month, corresponding to a total cost of 46.63 cents per American (2000 lb.) ton, or 25d. per English (2240 lb.) ton on the basis of American wages.

The average wage paid at Milwaukee is 62 cents (say, 2s. 7d.) per hour, and of course in comparison with British conditions, we have to remember that this is at least twice the wage paid in the United Kingdom, so that in this country the total labour cost would apparently not exceed about 1s. 2d. per ton.

TABLE VI.—(*A*) *Boiler House.*

Total Tons of coal consumed = 15,311 (2000 lb.), equivalent to 13,670 tons English (2240 lb.).

Class of labour.	No. of men.	Hours.	Rates.	Amount.	Total.	Cost per ton of coal consumed.
				Dols.		Cents.
First assistant engineer	1	115		98.81		
Boiler-room engineer	1	260.5		212.50		
Watch engineer	1	76		44.00		
Watch engineer	1	75		47.50		
Watch engineer	1	76		44.00		
Boiler-room assistant engineers	3	523		418.75		
Total	8	1125.5	.770		865.56	5.66
Furnace operator	1	224	.72	161.28		
Furnace operator	1	24	.71	17.04		
Furnace operator	1	247	.74	182.78		
Furnace operator	1	243	.68	165.24		
Furnace operator	2	472	.69	325.68		
Furnace operator	1	247	.60	148.20		
Furnace operator	1	116	.58	67.28		
Total	8	1573	.678		1067.50	6.97
Instrument man	1	197	.69	135.93	135.93	0.83
Boiler feed pump man	1	240	.58	139.20		
Boiler feed pump man	1	229	.67	153.43		
Boiler feed pump man	1	235	.74	173.90		
Total	4	704	.663		466.53	3.04
Oiler, feeder drives, &c.	1	178	.43	76.54		
Oiler, feeder drives, &c.	1	173	.61	105.53		
Oiler, feeder drives, &c.	1	63	.67	42.21		
Total	3	414	.542		224.28	1.46
Boiler-room helper	1	108	.47	50.76		
Boiler-room helper	1	220	.45	99.00		
Boiler-room helper	1	131	.43	56.33		
Boiler-room helper	1	132	.43	56.76		
Total	4	591	.445		262.85	1.72
Ashman	Total	81	.63	51.03		
Ashman	of 17	152	.61	92.72		
Ashman	men	772	.43	331.96		
Total	17	1005	.474		475.71	3.11
Miscellaneous labour, such as cleaning boiler plates, blow tubes, sweep, &c.	Total of 19 men	319	.63	200.97		
		520	.61	317.20		
		50	.67	33.50		
		7	.45	3.15		
		482	.43	207.26		
Total	19	1378	.554		762.08	4.96
Boiler-room total	63	6987.5	.610		4260.44	27.83

TABLE VII.—(*B*) *Pulverising House.*

Total tons of coal consumed = 15,311 (2000 lb.), equivalent to, say, 13,670 tons English (2240 lb.)

Class of labour.	No. of men.	Hours.	Rates.	Amount.	Total.	Cost per ton of coal consumed.
				Dols.		Cents.
Mill-room foreman	1	234.5	.80	187.50	187.50	1.22
Operator and maintenance man	1	176	.73	128.48		
Operator and maintenance man	1	150.5	.67	100.84		
Operator and maintenance man	1	114	.65	74.10		
Total	3	440.5	.688		303.42	1.98
Mill operator	1	223.5	.66	147.51		
Mill operator	1	230.5	.65	149.83		
Mill operator	1	224.0	.70	156.80		
Total	3	678.0	.670		454.14	2.96
Drier operator	1	208	.64	133.12		
Drier operator	1	224	.58	129.92		
Total	2	432	.608		263.04	1.72
Fuller-Kinyon pump man	1	234	.60	140.40		
Fuller-Kinyon pump man	2	445	.58	258.10		
Total	3	679	.587		398.50	2.60
Bin man	1	204	.60	122.40		
Bin man	1	150	.63	94.50		
Bin man	1	238	.56	133.28		
Total	3	592	.593		350.18	2.29
Relief man	1	170.5	.63	107.42	107.42	.70
Conveyor man, pulveriser house	1	96	.61	58.56		
Conveyor man, pulveriser house	1	216	.56	120.96		
Conveyor man, pulveriser house	1	207	.58	120.06		
Total	3	519	.578		299.58	1.96
Crusher, shaker, inclined conveyor, ting, cleaning and oiling	1	209	.64	133.76	299.58	1.96
	1	202	.65	127.26		
	1	186.5	.60	111.90		
	1	224	.64	143.36		
Total	4	821.5	.629		516.28	3.37
Pulverising house, total	23	4567.0	.631		2880.06	18.80
Total for complete boiler plant—						
Boiler-room	63	6987.5	.610		4260.44	27.83
Pulverising house	23	4567.0	.631		2880.06	18.80
Total	86	11,554.5	.618		7140.50	46.63

Maintenance and Repair of Pulverised Fuel.—As regards the wear and tear and cost of upkeep, the exact figures for the pulverising mills at Lakeside are as follows, taking the results of fifteen months' continuous running, March, 1921, to May, 1922, inclusive, during which 1830.46 tons (2000 lb.), equals 1634.30 English tons (2240 lb.) of coal was pulverised. The repairs included the following number of balls replaced in the pulverisers:—

	Balls.
Mill No. 1	12
Mill No. 2	17
Mill No. 3	13
Mill No. 4	12
Mill No. 5	16
Mill No. 6	6
Mill No. 7	9
Mill No. 8	4
Total	89

The price of these balls is 16.25 dollars each, which equals a total of 1446.25 dollars, which equals about 0.40d. per ton of coal for pulveriser ball replacement.

There were also replaced during the period October, 1921, to May, 1922, inclusive (eight months), two rings, one in No. 1 Mill and one in No. 2 Mill, at 420 dollars each, equals a total of 840.00 dollars,

A ROUMANIAN engineer, Dimitri Joanvici, has laid before the Premier of Quebec a project to keep the channel of the St. Lawrence River open for navigation all the winter. The details of his plan have not been made public.

Furnace for Brown Coal.

REFERRING to an article in our issue of February 16th last, under the title "Morwell Brown Coal and Electrical Scheme, Victoria, Australia," the Underfeed Stoker Company, Limited, sends us the drawing, reproduced below, of the furnace equipment for burning the Morwell brown coal.

The drawing shows the furnace of each boiler and indicates the brick arch construction, which is of special design to suit this peculiar fuel. The brown coal to be burned has the following analysis :—

Proximate Analyses.

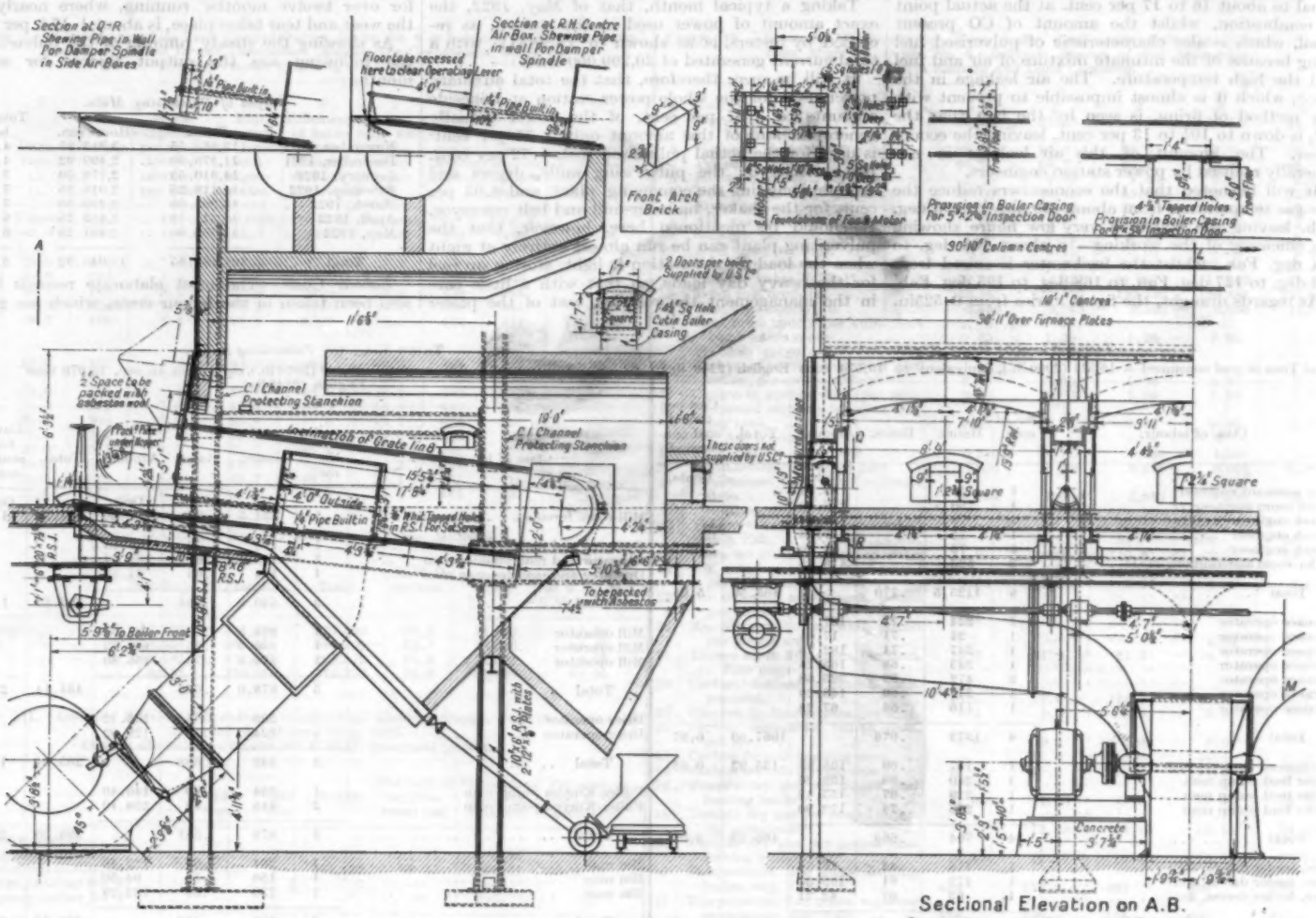
	Average limits. Per cent.		Typical average. Per cent.
Volatile hydrocarbons	25.0 ..	28.4	26.7
Fixed carbon	23.0 ..	25.3	24.2
Ash	2.0 ..	1.3	1.6
Moisture	50.0 ..	45.0	47.5
	100.0	100.0	100.0

Ultimate Analyses.

	Average limits. Per cent.		Typical average. Per cent.
Carbon	60.0 ..	65.5	62.75
Hydrogen	4.2 ..	5.0	4.6
Oxygen	30.5 ..	26.0	28.25
Nitrogen	.6 ..	.8	.7
Ash	4.0 ..	2.4	3.2
Sulphur	.7 ..	.3	.5
	100.0	100.0	100.0
Calorific value by bomb calorimeter, B.Th.U. per lb. (dry sample)	10,500 ..	11,500	11,000

This brown coal, as will be observed, contains as much as 50 per cent. of moisture, and in order to ignite it and burn it freely the heat of combustion has to be confined so that the temperature of the fuel bed may be raised very quickly to the ignition point and maintained at a temperature which will ensure rapid combustion.

In order to obtain the specified duty from the boilers it is necessary to burn this brown coal at a rate of combustion amounting to 70 lb. per square foot of grate. Each boiler is equipped with three forced draught travelling grate stokers, and the combined grate area per boiler is 366.9 square feet. As there are twelve boilers now being installed, there will be in all thirty-six mechanical stokers driven from a line shaft placed beneath the firing floor level. Each boiler has its own forced draught fan placed in the basement, delivering to the stoker air chambers.


Section at Q-R Shewing Pipe in Wall For Damper Spindle in Side Air Boxes
Section at R.H. Centre Air Box. Shewing Pipe in wall For Damper Spindle
Floor to be recessed here to clear Operating Lever
Front Arch Brick
Foundations of Face & Motor
Provision in Boiler Casing For 5"x7" Inspection Door
Provision in Boiler Casing For 4"x8" Inspection Door
4½" Tapped Holes
2 Doors per boiler Supplied by U.S.C.
Cast Iron Square
Cast Iron Sq Hole Case Boiler Casing
2" Space to be packed with Asbestos wool
C.I. Channel Protecting Stanchion
Centres of Grate Bars
These doors not supplied by U.S.C.
4'0" Outside
To be packed with Asbestos
To Boiler Front
Concrete
Section on L.M
Sectional Elevation on A.B.
Grate Area per Stoker = 122·3 sq ft
"THE ENGINEER"

BOILER FURNACE FOR BURNING MORWELL BROWN COAL

IN his preliminary report on the harbours of the Union of South Africa, Sir George Buchanan has recommended an expenditure of £3,750,000 for the development of Table Bay Harbour. Sir George at the same submitted a scheme which he says should be completed with the least possible delay.

The Sanitary Engineer and Mosquito Extermination.

SOME interesting particulars regarding a campaign against the malaria mosquito, initiated and carried out by engineers at the town of Carbondale, Illinois, were given in a paper recently read before the Illinois Society of Engineers, by Mr. Harry F. Ferguson, chief engineer of the Illinois State Board of Health. The author explained that in the State of Illinois land drainage work had been carried out for a number of years, and that it had greatly decreased the amount of malaria. Although the economic saving from decreased sickness and death from malaria—or from other diseases which may have attacked persons weakened by malaria—was not, he said, generally taken into consideration in drainage projects, the result should be included among the benefits resulting from drainage. In some cases this economic saving from decreased illness had, he added, exceeded the direct cost of the drainage work.

Vital statistics for Jackson County, in which Carbondale is situated, show the occurrence of from 2700 to 3000 cases of malaria annually. Assuming that the economic loss is £20 per case, the total loss in that one county is some £50,000 to £60,000 annually. The £20 per case, which includes doctor's bills, medicines and loss in productive earnings by the patients, is considered by Mr. Ferguson to be a conservative amount. Even so, the figures indicate that the county could well afford to spend a large sum yearly in eliminating mosquito-breeding places.

In the spring of 1922 the municipal authorities of Carbondale arranged to undertake complete control of the malaria mosquito in an area including the town itself and a district extending ½ mile beyond the town limits. The State Board of Health assigned sanitary engineers to plan and supervise the work. This campaign was very successful in controlling not only the malaria mosquito but also the other kinds which are merely a nuisance due to their stinging. In 1921 the town had 267 cases of malaria, or 4.26 per cent. of the population affected. At the end of the season's work in 1922, a house-to-house canvass showed 19 cases, or 0.3 per cent. of the population affected. The local doctors estimated 54 cases, but even if that figure be accepted, the result of the one season's work was remarkable.

A study of the situation showed that the mosquito-breeding places within mosquito-flight distance, included 60 acres of swamps on the north, a lake of 40 acres on the south, a number of small ponds and about 6 miles of ditches and streams. In addition, there was a great number of rain barrels and open wells and cisterns. To drain the swamps the Illinois Central Railway Company excavated a drainage ditch nearly 2 miles long, the line being interested in reducing the continual sickness among its employees living at Carbondale. This ditch was excavated by means of exploding dynamite charges, the work costing much less and being done much more rapidly than by hand, so that most of the swampy areas were drained before the height of the mosquito season. The lake was an ideal breeding place, as there was an abundant growth of weeds and pond lilies, together with grass around the shores. As a first step, the outlet was cut so as to lower the water level about 18in. Then the bays were cleared of weeds and growth. During the season the edges and portions of the surface were oiled at intervals. All ditches and watercourses were cleared out, and were oiled once a week. That these measures established almost complete control of natural breeding places was proved by frequent inspection.

The most troublesome part of the campaign was the control of rain barrels, wells and cisterns. Of 604 open wells and cisterns, 391 were found to be breeding places in June, and these were cleared by stocking them with small fish—*gambusia* or top-minnows being employed for this purpose. Of 1031 rain barrels and tubs, 830 were found to be breeding places, but by continual treatment and inspection, these were steadily reduced until practically perfect control had been obtained by the height of the mosquito season.

The total cost of the work, including that done by the railway and also the engineer's time and expenses, was about £850. It resulted in the prevention of at least 200 cases of malaria, and also relieved the mosquito nuisance. Estimating an economic loss of £20 for each case, as noted above, the net saving was at least £3150, or more than the entire cost of the permanent work and the seasonal work of inspection and treatment. Small expenditures in succeeding years will develop greater economic savings. Mr. Ferguson states that the results were so apparent as to lead the town to prepare for continuing the work this year, while a neighbouring city is planning to initiate similar control of the mosquito.

The natural history of the mosquito and the way in which malaria is spread by one particular kind of mosquito, were reviewed by Mr. Ferguson, and although they are comparatively well known they may, we think, be usefully referred to here. The two kinds or species of mosquitoes, are the *Anopheles*, the female of which can spread malaria, and the *Culex*, which is the ordinary and merely pestiferous insect. The life cycle of both is divided into four stages, the first three of which are entirely dependent upon water for their continuance. The entire cycle, from the egg to the adult, requires from seven to ten days, according to climatic conditions and the temperature of the water. The eggs are laid in water, those of the *Anopheles* being laid singly and those of the *Culex* in rafts of 200 to 300 eggs. In two or three days the eggs hatch in to the larvæ or "wigglers," which breathe air through respiratory siphons on their tails. There are considerable differences between the larvæ of the two species. The larvæ of the *Anopheles* swim horizontally on the surface and dart laterally when disturbed, while those of the *Culex* hang head downward at an angle of about 40 deg. with the water surface, only their tails protruding, and when disturbed they dart downward. In two or three days the larvæ develop into pupæ, and after another similar period the pupa splits and the adult mosquito emerges.

The *Anopheles* mosquito may be distinguished by the definite markings on the wings and by the fact that when resting or feeding its body and proboscis are in the same line and at an angle of 45 deg. to 90 deg. with the surface on which it is resting. The *Culex* mosquito has transparent wings and keeps its body parallel with the surface on which it rests.

Only the *Anopheles* mosquitoes and only the females of that species can spread malaria. The female must first

bite and suck the blood of a person infected with the disease. After the parasites of the disease have undergone certain changes in the body of the mosquito, have passed through the stomach walls and have reached the salivary glands, then the mosquito can spread malaria by injecting the animal parasites into the blood stream of a person it bites.

The fight against the mosquito must, Mr. Ferguson explained, be directed against its water stages, and particularly against the larvæ. The mosquito must be killed before it takes wing. Drainage is the most effective anti-mosquito measure, since removal of water eliminates the breeding places. In fact, Mr. Ferguson considers that at least 90 per cent. of the breeding can be destroyed by work of this kind. Swamps, marshes and ponds can be drained by ditches or tile drains. Ponds can be drained sometimes by vertical wells sunk through the bed to a permeable stratum. Old ditches should be dressed to proper gradients and have all grass and weeds kept away from the water. A small trench excavated in the bed of a ditch or stream will concentrate the dry-weather flow and will help to keep the grass and weeds on the banks from growing along the water. It will be more economical in some places to fill small depressions and pools.

Oil sprinkling or spraying should be used where neither drainage nor filling are practicable. It may be applied by sprinkling oil-soaked sawdust along the edges of the water, but spraying is most effective, this being done usually by a man carrying a knapsack sprayer with rubber hose and nozzle. Paraffin is effective and is easily spread, but as it evaporates with comparative rapidity, a mixture of 4 parts paraffin to 1 part crude oil is advisable. Oiling must be done at intervals of about seven days, as the oil evaporates and also breaks or separates so that a continuous film is not maintained. The oil acts directly as a poison, and indirectly by forming a film through which the larvæ cannot thrust their breathing tubes.

Another method is to mix dry paris green with fine dust in proportions of 2 to 100, and to let the wind distribute it over the marshy land. A third effective method is to stock ponds and lakes with the top minnows known as *Gambusia Affinis*, which swim near the surface of the water and devour the mosquito larvæ. Rain barrels and cisterns should be kept covered, and this can be controlled by house-to-house inspections, the passing of anti-mosquito ordinances, and the spread of educational information.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Pig Iron Situation.

THERE is no change in the pig iron situation in this district. Although there has been a drop in Cleveland prices, due to a temporary slackening in the local demand, Midland smelters who can sell much more iron than they can produce under present conditions, have not shown any disposition to relax their figures, and quotations of Northamptonshire, Nottinghamshire and Derbyshire irons remain at last week's level. Buyers, however, appear to have become a little less keen, there being a growing feeling that a break in prices cannot be long delayed. Pig iron interests are not indifferent to the turn which events are taking. A large part of the output has been sold over the next two months, however, and in these circumstances most of the smelters can afford to wait. The increase of output and the better assurance of coke being forthcoming to maintain the increase, are important factors in the situation. Moreover, the home trade is likely to get a larger proportion of the make than it has lately had, for foreign buyers are by no means so hungry for British pig iron as they were a month or so ago. The two furnaces which have been restarted in Staffordshire will not provide any addition to the supply in the open market, though there is said to be some Staffordshire No. 3 becoming available in small quantities at round about £5 15s. Quotations for Derbyshire, Northamptonshire and Nottinghamshire foundry iron are maintained at about £5 10s., whilst forge iron, the demand for which has improved, is quoted at £5.

Steel Values Depreciating.

Steel business has slowed down except in so far as it touches the wagon building industry, business in which shows a tendency to increase. Buyers are holding off in most departments, confident that prices will have to come down, and in the steel market, more even than in the iron, signs are not wanting of a coming reaction in prices. Billet values have further declined. Present requirements have been satisfied, and though there is no general pressure to sell such offers of supplies as are made elicit scarcely any response. In the circumstances, it is very difficult to say what the ruling price is. Various figures, from £9 upwards, are mentioned, but consumers are content to watch developments. Small steel bars have further receded from the £12 mark, the highest price now obtainable being about £11 15s., with most makers willing to accept £11 10s. Even this figure is not the minimum, however. There is no definite change in structural steel prices, most makers offering a firm resistance to consumers' requests for reductions. Some merchants, however, are stated to be accepting 5s. per ton less for angles and joists. There is some competition from mills in the north. They are quoting prices which, taking carriage into account, are on a level with those of Midland firms. Continental supplies are increasing in volume, and Belgian firms are making strenuous efforts to recover a footing in the market. They are offering material at much reduced prices. Latterly the quantities which the Continent was in a position to supply, were not proportionate to the activity with which offers were forced on the attention of the market. Steel bars and billets are, however, now offered in larger quantities, the former at £10, against the home price of £11 10s., and billets at £9.

Wire.

The demand for wire and wire materials is maintained. Wire rods are not offered very freely, and command about £13 10s. for soft qualities. The finished wire trade is a bright spot in the market. The mills are working to their full capacity, and for some descriptions are booked for three months ahead. The makers of spring wire for the mattress and upholstery trades are experiencing an improving business.

Belgian Nut and Bolt Bars.

A feature of the week is the desperate efforts which have been made by Belgian shippers to secure a portion of the orders which have of late been going from the Black Country nut and bolt trade almost exclusively to Staffordshire mills. Continental material for some time past has not commanded much attention on account of the small advantage offered in price and the great difficulties with regard to delivery. This week Belgian nut and bolt bars are being quoted at a much reduced rate. They can be obtained at less than £10 per ton delivered here. The quantities on offer are not large, and deliveries still remain more or less uncertain, though four to six weeks is given as a likely period. The price is a temptation to consumers who can afford to wait, and this determined intervention cannot but cause deterioration in the home market. Although users prefer the English material, it is obvious that local firms cannot hope to maintain their position should the supply of imported material prove reliable. Staffordshire nut and bolt bars are offered at £11 10s., but higher quotations are not now heard of. Lancashire makers adhere to their quotation of £11 17s. 6d. Marked bar mills are finding a well sustained market for their output. Prices, ruled by dear pig iron and production costs generally, are firm at £14 10s. Merchant iron is quoted £12 10s. Iron gas tube strip is in good request at £13 5s. to £13 10s.

Good Demand for Sheets.

Sheet mills are well employed. For galvanised corrugated sheets there is an improving inquiry both at home and abroad, and makers are able to maintain the basis price of £19 10s. For black sheets there is a very strong demand. Export requirements are still large, whilst at home the motor and other manufacturing trades are taking a great deal of this material.

Trade Displacement.

It would appear from the statistics of imports and exports for the month of March that the displacement of trade which has been brought about by the troubles in the Rhur is not so great as has been generally supposed. Imports of iron and steel underwent an appreciable shrinkage in nearly all categories during the month, while exports expanded as compared with the previous month, though they were lower than in January. The returns also indicate that continental supplies of iron and steel have been coming into this country against the heavy contracts made about the turn of the year, at a rate which suggests that the crippling effects of the Rhur trouble on continental producers has been exaggerated.

Raw Iron Output.

It is very creditable to smelters to find that, notwithstanding the difficulties they have had to contend with in regard to fuel supplies, they were able during March to increase their output of pig iron to 633,600 tons, an achievement which has not been equalled since January, 1921. Of this quantity no less than 89,356 tons were exported, being 23,545 tons more than in the previous month. It is interesting to note in this connection that Belgium increased its share from 6333 tons to 8436 tons. France more than doubled its purchases, the total rising from 2520 tons to 5487 tons. Shipments to Italy were nearly quadrupled, jumping from 2235 tons to 8345 tons. The East Indies took only 690 tons, other countries, which are unspecified, absorbing 66,398 tons, or considerably more than two-thirds of the whole.

Constructional Engineering.

Though owing to the high price of materials many constructional undertakings are being held up, the number of contracts being given out is increasing. Midland firms are getting some fairly good contracts for public works, chiefly for bridges in connection with road-widening schemes. The orders are of somewhat small dimensions, but it is believed that there is a very solid amount of business which will come into the market as soon as values return to a more normal level.

Trade Improvement in Wednesbury District.

There has been a gradual improvement in the Wednesbury and Darlaston industries of late, and there is every prospect, manufacturers think, of the steady trade advance being permanent. The promised reopening of the Old Park Works has not yet fully materialised, but a number of men have found employment there, and signs are not wanting that a revival is imminent. One of the largest works in Darlaston has started a night turn, while fresh orders are reaching other works in encouraging numbers.

Cannock Chase Miners' Earnings.

Miners engaged in the Cannock Chase coalfield are to receive a substantial increase in wages during May and June. Stallmen who in March and April received 9s. 6d., will get 10s. 2d., firemen who received 12s. 1d., now become entitled to 12s. 11d., and examiners wages are to be increased from 11s. 3d. to 12s. All other grades of pit workers will also receive additions.

Wagon Builders and New Wages Memorandum.

It is satisfactory to be able to record this week that the result of the ballot among the workers in the railway wagon building and repairing trades on the new wages proposals is in favour of acceptance. The workers have, by a majority of 2000, endorsed their leaders' recommendation for the acceptance of the memorandum agreed to in Birmingham on April 11th, and steps have been taken to confirm this memorandum with the employers, so that wages in the industry remain stabilised to March 31st, 1924. The various Midland wagon building firms are at the moment well employed, and now that the labour outlook is cleared, business should proceed apace.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Thursday.

General Outlook.

THE general condition of the markets this week is certainly not so good as it was. It is difficult to see exactly what is causing the dulness and depression, and it is possible that there are a good many causes working together, amongst which may be reckoned an increasing doubt as to the stability of prices, more especially in the iron and steel sections of the trade. The amount of business being done is very small, and prices, both in ferrous and non-ferrous metals, show a tendency to sag. The apprehension of lower prices has a worse effect on the minds of buyers than any actual reduction, for the latter will, in any case, tempt some buyers to operate.

Metals.

The market for standard copper has been easier, and prices have come down to a certain extent. The fall is not yet serious, and there is a belief that the market will pick up again very shortly, more especially if the trouble between France and Germany should show signs of coming to an end. The falling off of the buying for the German markets has been no doubt one factor in the weakening of the copper market, and the general decline of activity in the iron and steel trades may be another factor. Certainly in Manchester there has been less buying recently, and the sagging of the prices acts as a deterrent even to to those who are in need of supplies. The excessive differences between raw and manufactured metals have also a bad effect on the market. The difference between the highest and the lowest prices of standard copper during April was over £4 per ton, but no reduction has been made in copper and brass tubes up to the time of writing; although some such reduction may be made before these lines are in print, unless the copper market should take a favourable turn. The actual cost of making brass has also been greatly reduced during April by the fall of nearly £5 per ton in spelter. Mechanical engineers in this district are complaining about the prices they are required to pay. The market for the scrap non-ferrous metals is quiet and rather depressed, and dealers here are buying at low prices, when they buy at all. In selling, however, they endeavour to get prices nearer to the real values of the metals. Consumers of scrap should take note of the fact that dealers are buying good gun-metal scrap at about £50 per ton. The cost of the mixing from new metals cannot be less than £80 per ton. The market for tin is in rather a nervous state. There was a recovery from the lowest point, but the market cannot be called strong, and it is noticeable that the "contango" for forward delivery has disappeared altogether. It is a question now whether a "back" will develop. Lead has been a weak market, and at one time foreign lead was offered at £25 per ton. There was, however, a little recovery from this point. The total fall in lead during April was £3 per ton. This, however, was less than the fall in spelter, for which the demand has been very poor of late. The sharp rise in galvanised sheet prices, mainly caused by the advance in steel, seems to have checked buying.

Pig Iron.

The markets here for pig iron are very quiet, and there is practically no business of importance being done. There is no doubt that sellers are easier in their ideas as to prices, but not nearly sufficiently so to satisfy buyers, who have rather extravagant ideas as to the extent to which prices ought to come down. It might now be possible to buy Midland No. 3 foundry iron on the basis of 105s. per ton at the furnaces; and perhaps lower than this if consumers were willing to place contracts with merchants for delivery over the second half of the year. There are several merchants anxious to get out some "bear" sales, but buyers are shy of any such business. The idea here is that the pressure for shipment of iron and steel, resulting from the stoppage on the Continent, is now nearly over; and, of course, if this be true, much lower prices in Great Britain are inevitable; but one is not yet quite sure that the idea is true. The demand for iron up in the Cleveland district is much less than it was, but no further alteration of the Cleveland price was announced up to the time of writing.

Finished Steel.

The market here for manufactured steel is again easier, but the prices in the Manchester district are still considerably higher than those reported from other places. It is said that £9 10s. has been quoted for steel plates, although this is no doubt an extreme price. In Manchester sellers of steel plates were quoting £11, although possibly £10 15s. would have been taken. Not so long ago Midland makers were very firm at £11 10s., so the reader can see that there has been considerable weakening. The reason is no doubt that the works are getting through their orders, and a fresh supply of specifications is not coming in so well as was expected. The continental demand seems to be falling away, and although this does not affect Manchester directly, it reacts upon Manchester prices, because the works dependent upon it are looking elsewhere for business.

Scrap.

There is no improvement here in the market for

old material. Buyers of heavy wrought scrap are more indifferent than they were, and it is rather doubtful now whether £5 per ton could be obtained at the Lancashire ironworks. Heavy steel melting scrap is quiet and not worth more than 90s. on trucks. As for cast scrap there is practically nothing being done, although dealers offer it at fully 20s. per ton below the cost of common pig iron.

Edwin W. Buckley.

Much regret is felt by engineers in this district at the untimely death of Mr. Edwin W. Buckley, the manager of Mather and Platts, at the age of fifty-three. Mr. Buckley served his apprenticeship with this firm at its original works in Salford. After some experience in marine engineering he entered the service of Dowson, Taylor and Co. as works manager. In 1899 that firm was merged in the reconstituted present firm of Mather and Platt, Limited, and Mr. Buckley shortly afterwards became general manager. Mr. Buckley devoted himself entirely to the larger affairs of his firm, and took very little interest in public work beyond those measures which had to do with the betterment of the workpeople. The Manchester and Salford Hospital Saturday and Convalescent Homes Fund owes much of its great success to the interest taken in it by Mr. Buckley, who was one of its originators. Of this movement, the men's home is at Deganwy, and the women's home at Arnside. In association with Mr. John Taylor, managing director of Dowson, Taylor and Co., and now of Mather and Platt, Limited, Mr. Buckley was connected with many inventions that have proved very successful and of world-wide importance.

Chain Pumps for Sewage Works.

I recently had an opportunity of inspecting an interesting application of a chain pump which has been installed by Messrs. Webb and Hatch, Manchester, at the sewage works of the Altrincham Urban District Council, for lifting semi-solid matter. The pump has been in use for some time emptying the settling tanks and lagoons after the raw sewage has settled and the effluent has been run off. The semi-solid matter left behind is lifted from a sump under the pump room to a height of 17ft. by means of the Aquatole chain pump, and is discharged through a chute on to the land for drying, after which it is carted away and used for manurial purposes. The chain, composed of helical coils of wire, hinged together horizontally, is 12in. wide, and when running at a speed of 626ft. per minute, is capable of lifting about 20,000 gallons of liquid per hour. It is driven by a small gas engine and countershaft with a fast and loose pulley, and works with little or no attention and complete freedom from breakdowns.

A Long Service Association.

A new Association has been formed at the Metropolitan-Vickers Electrical Company's Works at Trafford Park, the members of which can all show twenty years' service or more. It speaks well for the conditions of service with the company, when it is recorded that there are already 302 members of this Association, the majority of whom, including ten women, are workpeople. On Monday, April 30th, the Association held its first dinner and social evening at the works. The two toasts of the evening were the "Metropolitan-Vickers Electrical Company, Limited," and the "Metropolitan-Vickers Long Service Association." The first of these was responded to by the managing director, Captain R. S. Hilton, who took the chair; and the second by Mr. S. Ratcliffe, J.P., one of the oldest employees of the company, and chairman of the Works Committee. A humorous entertainment was provided by Mr. H. Ward, and a very enjoyable evening was spent, which concluded with the singing of "Auld Lang Syne."

Manchester College of Technology.

At a meeting of the City Council held last week the fees charged to students at the Municipal College of Technology came up for discussion. The new scale of fees recommended by the Education Committee was as follows:—(1) For children of Manchester ratepayers, £40 per annum; (2) for children of ratepayers living in areas in Lancashire and Cheshire which make grants in aid to the Manchester Education Committee in respect of such students, £40; (3) for students living outside such areas but within the United Kingdom and Ireland, £50; (4) for students outside the United Kingdom and Ireland, £60. The new scale gave rise to a sharp discussion, and ultimately an amendment was carried that students in category two should be raised to £50, while those in category three should be raised to £60. In opposing the amendment, Alderman W. Walker, one of the few engineers on the council, contrasted the methods of American technical colleges with those at Manchester. He said the American colleges offered tuition free, or on very easy terms, to students from other parts of the world, because those in authority were shrewd enough to know that in this way they were training potential buyers of industrial equipment in American tradition and practice. He urged that it was to the advantage of Manchester industries that students from outside should come for training to the Manchester College.

BARROW-IN-FURNESS, Thursday.

Hematite.

A slight change has come over the hematite iron trade. There does not seem to be the same intense desire to secure delivery on the part of some buyers. The coke question is still interesting, but there is every sign of an easing off in the shortage, and this is creating more confidence in the market. There is no lack of orders, and all smelters are well fixed for business for the next few months with the present number of furnaces in blast, and there is talk of one or two more going into business as soon as the supply of coke permits of it. Certainly the Rhur affair is still affecting the market, but not to the same extent. Prices have a downward tendency, and this in itself is a sign of the new conditions which are prevailing. The trade is secure, but shows a tendency to assume a more normal condition. Business in special qualities of iron continues to be good. There is also a fair trade in ingot moulds with South Wales. The shipments of pig iron from Barrow during the past week have not been heavy.

Iron Ore.

The iron ore trade continues to be fairly good, and in the Cumberland districts the work at the mines is practically normal. A certain quantity is going out of the district, but the large proportion is consumed at local ironworks. Foreign ore comes in in limited quantities in view of stocks at the docks. Another cargo arrived from Kirkenes last week.

Steel.

The steel trade is only moderate. Barrow still has the rail mills engaged, and the hoop and small bar mills are also well booked for orders. Workington is engaged in the tire department, but the rail mills are idle again. The foundries are better engaged, and the prospect is better.

SHEFFIELD.

(From our own Correspondent.)

Increased Output of Open-hearth Steel.

SHEFFIELD trade continues in much the same condition as previously described. While heavy steel is enjoying a period of great activity, other branches remain in an unsatisfactory condition. The unemployment figures continue to fall, but the process is a very slow one. The last weekly decrease was only 291, and there are still 29,114 names on the registers of the employment exchange. The open-hearth steel department has shown further expansion since my last letter, Steel, Peech and Tozer, of Rotherham, having lighted another of their 50-ton furnaces. Nine furnaces are now in operation out of a range of fourteen, which have all been built since 1917, and the production is upwards of 5000 tons per week. At the works of Samuel Fox and Co., Stocksbridge, at the Parkgate Works, and at Cammell's establishment at Penistone the output of open-hearth steel is not far short of full capacity, and, so far as both basic and acid qualities are concerned, the production of Sheffield and district is now much above the pre-war average. The placing of new orders is still on a small scale, but the furnaces and mills have enough work on hand to last several weeks in respect of billets, and a considerably longer period in respect of bars, plates and rods.

The Lighter Steel Trades.

Apart from crude steel, pig iron and fuel, there is no improvement to report, but rather a deterioration. While business is certainly a good deal better than it was last year at this time, it is far from satisfactory, and the promise with which the year opened has not been realised. The crucible steel trade has been in a state of depression for three years, and shows little sign of recovery. Only a few firms have enough orders on hand to keep them regularly employed, and the majority of the others are very badly situated. In the file trade, which has been very severely hit, things looked up a bit early in the year, but the movement has not been continued, and for the limited quantity of business available there is keen competition and a considerable amount of price-cutting.

Cutlery and Plate.

I cannot send any brighter report of the state of the cutlery and plate branches. There has been a decline in the demand even for stainless knives, especially those of the best quality. The bulk of the work being done is on cheap and inferior grades, and competition is so keen that orders are taken at very low prices. A fair amount of business is being done in the old-style double-shear cutlery. The German competition which has so severely hit pen and pocket cutlery for a long time is now less acute, and some firms report that March was the best month they had had in this department for two years. Activity is not quite so well maintained at present however. There is considerable slackness in silver and electroplate, although a fair demand is still experienced for spoons and forks.

Hull Ships and Goole Docks.

Hull has just established a good record as a shipbuilding centre by its prompt delivery of two vessels to the Eastern Steamship Company of Canada, to form part of its fleet for the Canadian Lakes. The vessels, which have been built by Earle's Shipbuilding and Engineering Company, are the Robert W. Pomeroy and the John J. Rammacher. They were urgently wanted for the coming season's grain trade on the Canadian Lakes, and they have both been completed and handed over in record time, some weeks before the specified dates for delivery. Hull's neighbouring port of Goole is suffering from congestion at the docks, and there is strong complaint that the existing loading facilities are inadequate. At a meeting of the Council of the Goole Chamber of Commerce and Shipping, one member expressed the conviction that the shortage of hoists was the cause of the congestion, while another pointed out that on the last occasion when a 1000-ton ship went under the 50-ton hoist it took sixteen hours to load. It was decided to write to the London, Midland and Scottish Railway Company pressing for additional facilities.

Gas and Sewage Schemes.

The renewal of the carbonising plant at Chesterfield Central Gasworks is proposed by the Corporation. As the first instalment, Mr. H. Davies, the gas engineer, has been instructed to submit plans and estimates for the erection of six beds, each of ten 20ft. horizontal retorts, with the necessary coal and coke-handling plant. At Barnsley there has been a Ministry of Health inquiry into an application of the Corporation for sanction to borrow £21,650 for the purpose of centralising the five sewage works in the extended borough. There was no opposition to the scheme. At a meeting of the West Riding Rivers Board it was reported that Sheffield had made very good progress with the second instalment of its bio-aeration plant for the treatment of sewage, and a third instalment was well advanced; while at Rotherham the first 1,000,000-gallon bio-aeration plant was almost completed, and a good start had been made with the second unit.

NORTH OF ENGLAND.

(From our own Correspondent.)

The Crisis in the Shipyards.

THE crisis in the shipbuilding industry caused by the refusal of the boilermakers to accept the national agreement on overtime and night-shift work could not have come at a more unfortunate time, for most of the shipyards on the North-East Coast had just commenced operations again after a long period of idleness. With two or three exceptions, the whole of the yards on the North-East Coast are involved, and although at the time of writing the dispute is confined to the boilermakers, other classes of labour will soon be thrown idle. On the Tyne, where the dispute began, and where a strike has been in progress for some time, the seriousness of the position is already reflected in the shipyards. The ship-repairing industry is most seriously affected. Very little new work was on hand at some of the yards, owing to the depressed state of the shipbuilding industry, but the outlook was more hopeful, and it is stated that new work which was just about to be laid down would have found employment for many additional men. Dissatisfaction is expressed at the position which has been created, as some of the men assert, by the action of their leaders. In the opinion of many, there was no adequate reason why the men should have been deprived of work. One important repair contract has already been lost to the Tyne owing to the dispute, the large oil-carrying vessel Saranic having left for Rotterdam. The vessel, which required several thousand pounds' worth of repairs, was already in dock, and the owners waited until the last moment before they decided to send her away. About 10,000 men are affected on the Tyne, 2000 on the Wear and over 1000 on the Tees. It is contended by the employers that nightwork and overtime are indispensable factors in shipyard employment, which is largely devoted to the execution of orders within a definite time limit. Any attempt to abolish or even restrict unnecessarily such nightwork or overtime is regarded as "kill-trade." The setback caused by this stoppage will unquestionably have far-reaching results.

Steel Exports Reach Pre-War Level.

The return of exports for March affords encouragement to those interested in the prosperity of the iron and steel trade of the Cleveland district. The most notable fact that emerges is that for the first time since the war the exports of manufactured iron and steel from Cleveland have exceeded 60,000 tons. The precise total is 62,423 tons, and one has to go back to May, 1914, to find a parallel to such a huge volume of exports. It represents an advance of over 5600 tons on the March figure, and includes a total of 21,568 tons to India and Ceylon alone. To Japan and also to Egypt the shipments have been heavy, and new avenues of trade have been opened up in various parts of the world. The fact that Scottish pig iron has been cheaper than that of Cleveland has led to a big contraction in the pig iron shipments to Scotland. Only 6968 tons were shipped during April, as compared with 13,730 tons in March. But a larger quantity was sent to South Wales, and whilst the aggregate export of 54,435 tons of pig iron from the district was 13,203 tons less than in March, it was approximately 10,000 tons more than the monthly average for last year. Germany received 13,792 tons, the United States 8000 tons, Belgium 6420 tons and France 4876 tons. The aggregate exports of pig iron, manufactured iron and steel for the month totalled 116,858 tons, compared with 124,410 tons in March, a decrease of 7552 tons.

Cleveland Iron Market.

The Cleveland pig iron market presents few new features of moment. There is no longer any great pressure for supplies, current needs being covered by running contracts, and consumers appear content to mark time in the hope of a further concession in prices. So long as fuel costs are so high, however, pig iron prices can scarcely fall very far, and, moreover, producers are faced with the certain prospect of the next wage adjustment under the sliding scale adding substantially to wage costs in the industry. Still, consumers hold to the belief that makers may be compelled by events to cut prices further. Quotations stand as follows:—No. 1, 130s.; No. 3 G.M.B., 125s.; No. 4 foundry, 120s.; No. 4 forge, 117s. 6d.

Hematite Pig Iron.

The position in the East Coast hematite pig iron trade is easier, and business is hardly so brisk. Mixed numbers are offered at 122s. 6d. per ton, and with two more furnaces being put into operation there is rather a pressure to sell. But at 122s. 6d. per ton, hematite is again actually cheaper than foundry iron, and will no doubt be used wherever possible as a measure of economy.

Iron-making Materials.

The foreign ore trade is exceedingly quiet, but it is expected that consumers will soon need to replenish their supplies. At the moment, however, they are holding off the market and will not consider offers. Under these circumstances, the sellers' quotation of 24s. 6d. per ton for best Rubio ore c.i.f. Tees is purely nominal. There is a firmer tendency in the coke market. Sellers of Durham furnace qualities put the price at not less than 44s. per ton delivered at the works, and even at that figure only old customers can be supplied, all the surplus going abroad at much higher prices.

Manufactured Iron and Steel.

Although business in the manufactured iron and steel trade is not brisk, a moderate volume of orders is being placed, and manufacturers adhere firmly to recent quotations. A little more continental material is being offered, but this competition has not yet developed serious proportions, and the steel makers are fairly well placed for orders.

The Coal Trade.

There are few, if any, changes apparent in the Northern coal trade situation. Everything seems as tight as a drum. Supplies are abnormally scarce up to the end of June, and, as a result of the ever-increasing pressure for supplies the collieries are in a position to control the market as to prices. So far as can be gauged, there is no immediate sign or prospect of relaxation. There is a certain amount of attention paid to American competition, which just now is making itself felt, though prices so far have not been affected to any appreciable extent. This, of course, is entirely attributed to the heavy continental demand for coal of every kind, which up to now cannot be overtaken. If the Ruhr occupation question were disposed of, so that the German collieries were able to work fully and their output was more or less available for German factories, there is no doubt that values would soon show signs of retrogression. At the moment, the demand on the Northern market far and away exceeds the supply, either actual or prospective, and as the bulk of the miners observed Tuesday as a May Day holiday, the scarcity has become more accentuated. Northumberland steam coals are scarce and strong. Both best and second brands of screened and smalls are at top prices, when any is obtainable. Durham gas coals have firmed up and are still tightening, while coking coal is unobtainable and bunkers are inclined to advance still further. The coke market is stronger for all foundry and furnace makes, but gas coke is quiet and easy.

SCOTLAND.

(From our own Correspondent.)

Shipbuilding—Increased Output.

THE returns for the month of April indicated an increase of nearly 20,000 tons over the March output from Clyde shipyards. The total of fifteen vessels, of 51,713 tons aggregate, however, though larger than for the corresponding period of last year, is still far behind the figures for similar periods in other former years. Chief amongst the vessels launched were the following:—California, t.s., geared turbine, 17,250 tons, for the Anchor Line; Scottish Borderer, t.s., motor ship, 7100 tons, for Tankers, Limited, London; Laguna, t.s., motor ship, 6500 tons, for the Pacific Steam Navigation Company, Liverpool; Dorelian, 6440 tons, for Messrs. Frederick Leyland and Co., Liverpool; Nurjehan, 5450 tons, for the Asiatic Steam Navigation Company, London.

Clouded Outlook.

Just when the shipbuilding industry appeared to be taking a new lease of life circumstances have arisen which threaten to dissipate all hopeful signs. The lock-out has not meant an immediate closing down of the yards, but this must inevitably follow if the dispute is continued even a short period. For some time now inquiries have been frequent enough, but orders have been scarce; but shipbuilders have been fairly confident that better times were at hand. A number of small orders were placed during April, while just as the month closed a contract for three P. and O. steamers, to be built at Greenock, was announced. Meanwhile, the position is completely altered, and until the present trouble is arranged, inquiries and orders are bound to be held up if only from the impossibility of naming time of delivery. Not only so, but the work already on hand may suffer delay, which must affect progress for months to come should the closing of yards become imperative.

Greenock and Motherwell.

The placing of the contract for the P. and O. steamers will mean a considerable amount of work for Greenock and Motherwell. The vessels will be built at Greenock by Messrs. Harland and Wolff. The plates, &c., will be manufactured at Motherwell, and the Clydebridge works at Cambuslang will also have a share. Some time ago Messrs. Harland and Wolff acquired a controlling interest in these works, which were formerly owned by Messrs. Colville.

Steel and Iron.

Fair export inquiries are reported for steel and iron for export, but so far as firm orders are concerned the market is quiet. Apart from high prices, the situation on the Continent is causing uneasiness to producers and consumers alike. The works are comparatively well occupied at present on booked orders, but the scarcity of new contracts gives rise to some anxiety. Apart from sheets steel material is not receiving satisfactory attention, and wherever possible makers are apparently inclined to shade prices. Bar iron makers are doing a fair business on home account with wagon builders and structural engineers, but the export demand is lessening. For the latter some makers blame larger offerings of continental material at lower than local prices. Re-rolled steel bars are quieter, but a good market is being found for strips. The demand for scrap is easing, and quotations are inclined to weaken.

Coal.

The majority of the collieries have still plenty to do to overtake orders placed during the "boom" period, and are still in a position to maintain prices on a high level. Consequently with little prompt fuel available, the market for new business is very slow. The dulness has been relieved to some extent by offerings of second-hand fuel at more advantageous prices to buyers. These transactions are largely confined to large coals. Washed nuts of all descriptions are heavily booked, and no difficulty is experienced in maintaining prices. The congestion at the loading ports on the east coast is now less prominent in the Fifeshire area, but the situation in the Lothians is still serious. Aggregate shipments for the past week amounted to 347,329 tons, against 386,252 tons in the preceding week, and 214,173 tons in the same week last year. As a result of the report in colliery workings during January and February of this year, the wages paid to miners during May and June in Lanarkshire will show an increase of 4d. per shift compared with March and April, and representing a figure 132.82 per cent. above the 1888 basis rates.

New Fifeshire Coalfield.

It is announced that new mining operations have been carried out by Messrs. The Wilsons and Clyde Coal Company at Saline, in Fifeshire, as a result of which two shafts will be sunk immediately. The new workings will open up a large coalfield hitherto untouched.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Position.

THE conditions prevailing in the steam coal trade are quieter from the point of view of the general inquiry, but prices are in all the circumstances well maintained. It is recognised that this is a short month, seeing that the Whitsuntide holidays intervene, and the probability is that the majority of shippers will endeavour to get their cargoes away before the holidays, as otherwise there is the risk that shipments may not be effected within the period of their sales. Furthermore, it is not unlikely that there may be further trouble in the coalfield in the course of a week or so on the non-unionist question, and limitation of output will have the effect of assisting to steady prices. At the same time, although the market is not by any means bare of orders, all the information goes to show that the general importer abroad is not disposed to pay the present market price of coal, plus the cost of freight. There are several inquiries for coals for delivery over the next few months and over the second half of the year; but the demand for prompt cargoes is somewhat limited, and only exporters with low-priced contracts can conclude sales and at the same time make any profit. Some interesting remarks on the question of the high price of coal were made at the monthly meeting of the Cardiff Chamber of Commerce on Tuesday, when Mr. W. North Lewis said that he could not help feeling that it would be wise on the part of boards of colliery directors to discourage or, at all events, not to encourage their sales agents to squeeze the last farthing out of the buyer when they had the market at their mercy, as had been done during the last couple of months. He was not at all sure that these exceedingly high prices would be for the ultimate good of the coal trade. This expression of opinion coming from a coalowner is interesting, but it only confirms the view often held by the middleman who has to find the market abroad. It has frequently been the complaint of regular consumers of coal on the Continent that they have been called upon to pay prices out of all reason, simply because an abnormal demand for Welsh coal has sprung up from an unexpected quarter, as, for instance, from Germany recently, owing to the occupation of the Ruhr by the French. There is a good deal in what Mr. North Lewis stated, and there is no doubt that a good steady trade is, in the long run, much more preferable to a sudden burst of activity followed by a period of comparative depression.

Three-shift Question.

Nothing definite has been arrived at on the three-shift problem at South Wales docks, but negotiations have been continued. Delegates from all parts of the Bristol Channel met at Cardiff on Tuesday to receive a report from the men's side of the negotiating committee. This having been submitted and discussed, the heads of agreement arrived at under the chairmanship of Mr. J. A. Compston, who presided at the Court of Inquiry instituted by the Ministry of Labour, were accepted in principle; but there are many points of interpretation which require settling by further conferences with the employers, and therefore steps are being taken to arrange a date of meeting.

Miners' Wages.

An official announcement by the secretary of the South Wales Coalowners' Association states that the certificate of the joint accountants for the South Wales coalfield for January and February combined shows that after allowing for the cost of the standard wages, other costs and the owners' standard profits of 17 per cent., the surplus available is £854,608. The certified percentage payable for April and May is 26.05 per cent. on the 1915 standard rates, compared with 13.73 per cent. under the previous audit. The owners under the terms of the national agreement are under an obligation to pay the minimum wage of 28 per cent. on the 1915 standard, and to do this may have to forego £71,519 of their profits. This brings the total amount sacrificed by the owners under the minimum wage clause since November, 1921, to £3,410,000. The percentage on the 1915 standard rates is the highest which has been certified by the joint auditors under the national agreement of 1921, and it gives unmistakable evidence of the continued improvement in the state of the coal export trade. The output in January was the highest reached in any month since the war. The wages in July and August will be regulated by the proceeds for March and April. There is every probability that the audit for those two months will show a very substantial surplus, notwithstanding the Easter holidays and the regrettable loss of trade through non-unionist and other stoppages.

Oil Works Dispute.

Labour troubles are being experienced at the National Oil Refinery at Skewen. The trouble commenced on April 4th, when the fitters, who are members of the A.E.U. and about 100 in number, ceased work, their alleged grievance being that they were asked to work forty-seven hours a week, instead of forty-four, for the pay of forty-seven as hitherto. Three weeks after their mates had stopped, other men who had been employed on other jobs on the works came out in sympathy. According to the works manager, these men say that they have certain grievances, but up to the end of last week the works manager had not received any written communication from their leaders of any complaints. On Thursday in last week the works manager received a demand on behalf of the unskilled labourers for a working week of forty-four hours with three guineas pay, to which demand the company could not see its way to accede. The actual number of men out is 520, while there are about 1200 men at work.

Current Business.

The current demand for coal from the Continent is on the quiet side, but so far as the collieries are concerned, they are well sold, and it remains for the middlemen to stem up their requirements. Some of the collieries producing the best grades are firmly asking as much as 42s. 6d., as on paper they have no coal to spare; but middlemen are very glad to be able to dispose of any best Admiralty large coal which they may hold on low contract figures at 4s. to 5s. less. Superior smalls keep very steady at round about 30s. On the whole, there is not so much life in the market, but it is not expected that for this month prices will fall away to any appreciable extent, owing to the curtailed production resulting from the holidays. Anthracite coals are very steady, especially for sized coals and for duff and culm.

Latest News from the Provinces.

NORTH OF ENGLAND.

Ironworks Restart.

Two furnaces at the Thornaby Ironworks of W. Whitwell and Co., Limited, have now been lighted up, and the firm anticipates starting to manufacture iron again in the early part of next week. The works have been idle for several months. There are now forty-seven blast-furnaces operating on the North-East Coast.

Steel Order for Tees-side.

The Cargo Fleet Iron and Steel Company, Middlesbrough, has received an order from the Glasgow Corporation for 5000 tons of steel tramway rails at £11 per ton.

LAUNCHES AND TRIAL TRIPS.

DARDANUS, liner; built by Workman, Clark and Co., Limited, to the order of Messrs. Alfred Holt and Co.; dimensions, 470ft. by 58ft. by 35ft. 3in.; 10,000 tons deadweight. Engines, Brown Curtis geared turbines; constructed by the builders; launch, April 16th.

LAGUNA, twin-screw motor vessel; built by Harland and Wolff, Limited, to the order of the Pacific Steam Navigation Company; dimensions, 433ft. by 54ft. by 36ft.; 6500 gross tonnage. Engines, two six-cylinder, four-cycle Diesel oil; constructed by the builders; launch, April 19th.

CATALOGUES.

J. BLAKEBOROUGH AND SONS, Limited, Brighouse.—Catalogue No. 60, "Waterworks Appliances." An exceedingly well-illustrated and printed catalogue dealing with waterworks appliances of all sorts and kinds, including, amongst other things, reservoir outlet tower equipments for hand and power operation; taps, valves and penstocks of a multiplicity of designs and for various purposes; standpipes; ventilators; floating outlet arms; automatic filter regulators and devices; sand washers; fire and other hydrants; watering stand-posts; hose and hose couplings; drinking fountains; apparatus for drilling and tapping mains; pipe testing machines; meter testing apparatus; test pumps; pipe laying tools; weir gauges; rain gauges; pipe scrapers; surface boxes; special pipes, &c. &c. Also Catalogue No. 70, "Sewage Works Appliances," equally well got up and illustrated and dealing, amongst other things, with valves, penstocks and sluice gates of various kinds; floating outlet arms; telescopic draw-off pipes; dredger elevators for catchpits; screening and raking machines; chain pumps; sewage distributors; revolving spray jets; reagent mixing machines; flushing syphons; sewer ventilating shafts; manhole and lamp-hole covers, &c.

INSTITUTE OF TRANSPORT.—The Council of the Institute has elected the undernamed as officers for the year commencing October 1st, 1923:—President: Sir J. G. Broodbank; Past-presidents to serve on Council: The Right Hon. Lord Ashfield of Southwell, P.C., Sir Henry P. Maybury, K.C.M.G., C.B., and Sir Sam Fay; Vice-presidents: H. E. Blain, Sir J. E. Eaglesome, K.C.M.G., H. H. Gordon, E. S. Shrapnell-Smith, Sir Herbert Walker, K.C.B., Arthur Watson; Hon. Treasurer: Philip Burtt; Hon. Solicitor: The Right Hon. Sir William Joynson-Hicks, Bart., P.C., M.P. Mr. A. Winter Gray has been appointed Secretary of the Institute as from October 1st next, when Mr. H. E. Blain will relinquish the office of Honorary Secretary and become a vice-president.

THE INSTITUTION OF CIVIL ENGINEERS.—The Council of the Institution of Civil Engineers has made the following awards in respect of papers read and discussed at the ordinary meetings during the session 1922-1923:—Telford Medals to Mr. H. W. H. Richards (London) and Mr. E. O. Forster Brown (London); a George Stephenson Medal to Mr. Asa Binns, M. Inst. C.E. (London); a Watt Medal to Mr. A. B. Buckley, Jun., Assoc. M. Inst. C.E. (Winchester); Telford Premiums to Mr. W. A. Fraser, M. Inst. C.E. (Edinburgh); Mr. S. L. Rothery, Assoc. M. Inst. C.E. (Calexico, U.S.A.); Mr. Mark Randall (Johannesburg); and Mr. D. E. Lloyd-Davies, M. Inst. C.E. (Capetown); an Indian Premium to Mr. D. H. Remfrey, Assoc. M. Inst. C.E. (Calcutta); a Manby Premium to Mr. F. M. G. Du-Plat-Taylor, M. Inst. C.E. (London); and a Crampton Prize to Mr. F. W. Jameson (Kimberley).

Current Prices for Metals and Fuels.

IRON ORE.

N.W COAST—	
Native	26/-
(1) Spanish	24/-
(1) N. African	24/-
N.E. COAST—	
Native	—
Foreign (c.i.f.)	24/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	6 7 6	—
No. 1 Foundry	6 2 6	—
No. 3 Foundry	5 17 6	—
N.E. COAST—		
Hematite Mixed Nos.	6 5 0	6 5 0
No. 1	6 6 0	6 6 0
Cleveland—		
No. 1	6 10 0	6 10 0
Silicious Iron	6 10 0	6 10 0
No. 3 G.M.B.	6 5 0	6 5 0
No. 4 Foundry	6 2 6	6 2 6
No. 4 Forge	5 17 6	5 17 6
Mottled	—	—
White	—	—
MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	13 0 0	—
North Staffs. Forge *	—	—
,, ,, Foundry	5 12 6 to 5 15 0	
(3) Northampton—		
Foundry No. 3	5 8 0 to 5 10 0	
,, Forge	4 18 0 to 5 0 0	
(3) Derbyshire—		
No. 3 Foundry	5 5 0 to 5 7 6	—
Forge	5 0 0	—
(3) Lincolnshire—		
Basic (none offering)	6 0 0 to 6 10 0	
Foundry	5 10 0	—
Forge	5 5 0	—
(4) N.W. COAST—		
N. Lancs. and Cum.		
Hematite Mixed Nos.	7 0 0	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	12 10 0	—
Best ,,	—	—
N.E. COAST—		
Crown Bars	12 0 0	—
Tees	10 0 0	—
LANCS.—		
Crown Bars	12 15 0	—
Second Quality Bars	13 0 0	—
Hoops	15 0 0	14 15 0
S. YORKS.—		
Crown Bars	12 10 0	—
Best ,,	13 10 0	—
Hoops	15 10 0	—
MIDLANDS—		
Crown Bars	12 10 0	—
Marked Bars (Staffs.)	14 10 0	—
Nut and Bolt Bars	11 10 0	—
Gas Tube Strip	13 5 0 to 13 10 0	

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	13 0 0	—
Ship Plates ¾in. and up	10 5 0	—
Sections	10 0 0	—
Steel Sheets ⅛in. to ¾in.	12 10 0	—
Sheets (Gal. Cor. 24 B.G.)	—	20 0 0

STEEL (*continued*)

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	10 10 0	—
Angles	10 0 0	—
Boiler Plates	14 0 0	—
Joists	10 0	—
Heavy Rails	10 10 0	—
Fish-plates	14 10 0	—
Channels	9 5 0	—
Hard Billets	10 15 0	—
Soft Billets	10 10 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	10 0 0	—
Light ,,	12 10 0	—
Billets	11 0 0	—
MANCHESTER—		
Bars (Round)	12 0 0	—
,, (others)	11 0 0 to 11 5 0	
Hoops (Best)	15 5 0	15 0 0
,, (Soft Steel)	13 15 0	13 10 0
Plates	11 0 0 to 11 10 0	
,, (Lancs. Boiler)	13 10 0	—
SHEFFIELD—		
Siemens Acid Billets	13 0 0	—
Bessemer Billets	13 10 0	—
Hard Basic	10 15 0	—
Intermediate Basic	10 10 0	—
Soft Basic	9 10 0 to 10 0 0	
Hoops	12 15 0 to 13 5 0	
Soft Wire Rods	13 0 0 to 13 10 0	
MIDLANDS—		
Small Rolled Bars	11 10 0 to 11 15 0	
Billets and Sheet-bars	9 5 0 to 9 15 0	
Gas Tube Strip	12 0 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets (f.o.b. L'pool)	19 10 0	—
Angles	10 10 0	—
Joists	10 10 0	—
Tees	11 10 0	—
Bridge and Tank Plates	10 15 0 to 11 0 0	

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	24/3 to 25/-
Block Tin (cash)	£213 0 0
,, (three months)	£213 0 0
Copper (cash)	£69 15 0
,, (three months)	£70 10 0
Spanish Lead (cash)	£25 12 6
,, (three months)	£25 15 0
Spelter (cash)	£32 2 6
,, (three months)	£32 10 0
MANCHESTER—	
Copper, Best Selected Ingots	£75 0 0
,, Electrolytic	£79 10 0
,, Strong Sheets	£106 0 0
,, Loco Tubes	£0 1 2½
Brass Loco Tubes	£0 1 1
,, Condenser	£0 1 3½
Lead, English	£27 0 0
,, Foreign	£26 0 0

FERRO ALLOYS.

(All prices now nominal.)

	Per Ton.	Per Unit
Tungsten Metal Powder	1/11 per lb.	
Ferro Tungsten	1/5 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23	10/6
,, 6 p.c. to 8 p.c. ,,	£21 0 0	8/-
,, 8 p.c. to 10 p.c. ,,	£20 0 0	8/-
,, Specially Refined		
,, MAX. 2 p.c. carbon	£52 0 0	20/-
,, ,, 1 p.c. ,,	£62 0 0	22/6
,, ,, 0·75 p.c. carbon	£72 0 0	25/-
,, carbon free	1/6 per lb.	
Metallic Chromium	4/6 per lb.	
Ferro Manganese (per ton)	£16 for home.	
,, Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale 5/- per unit	
,, ,, 75 p.c.	£21 0 0 scale 6/- per unit	
,, Vanadium	17/- per lb.	
,, Molybdenum	9/6 per lb.	
,, Titanium (carbon free)	1/1 per lb.	
Nickel (per ton)	£130	
Cobalt	12/- per lb.	
Aluminium (per ton)	£82 to £100 (British Official.)	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	26/6
,, ,, Ell	28/6
,, ,, Splint	30/- to 32/6
,, ,, Trebles	30/6
,, ,, Doubles	29/6
,, ,, Singles	29/-
AYRSHIRE—	
(f.o.b. Ports)—Steam	26/6
,, ,, Splint	30/-
,, ,, Trebles	30/6
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	26/6 to 30/-
Screened Navigation	33/-
Trebles	30/6
Doubles	30/-
Singles	29/6
LOTHIANS—	
(f.o.b. Leith)—Best Steam	29/6
Secondary Steam	27/6
Trebles	30/6
Doubles	30/-
Singles	29/6

ENGLAND.

(8) N.W. COAST—	
Steams	31/6
Household	46/6 to 57/6
Coke	48/-
NORTHUMBERLAND—	
Best Steams	34/6 to 35/-
Second Steams	32/6 to 33/6
Steam Smalls	23/- to 25/-
Unscreened	29/6
Household	25/- to 26/-
DURHAM—	
Best Gas	33/- to 35/-
Second	32/6
Household	25/- to 28/-
Foundry Coke	70/- to 75/-

	INLAND.
SHEFFIELD—	
Best Hand-picked Branch	32/6 to 34/6 —
Barnsley Best Silkstone	28/- to 30/- —
Derbyshire Best Brights	25/6 to 27/6 —
,, ,, House	23/- to 24/6 —
,, ,, Large Nuts	20/6 to 22/6 —
,, ,, Small ,,	18/- to 21/- —
Yorkshire Hards	22/- to 24/- —
Derbyshire ,,	21/- to 24/- —
Rough Slacks	12/- to 14/- —
Nutty ,,	10/6 to 12/6 —
Smalls	7/- to 9/- —
Blast Furnace Coke (Inland)	24/- to 27/-
,, ,, ,, (Export) f.o.b.	44/ to 47/-

(9) SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Smokeless Large	40/- to 42/6
Second ,, ,,	37/6 to 39/-
Best Dry Large	37/6 to 40/-
Ordinary Dry Large	35/- to 37/6
Best Black Vein Large	39/- to 40/-
Western Valley ,,	39/- to 40/-
Best Eastern Valley Large	38/- to 39/-
Ordinary ,, ,,	33/- to 35/-
Best Steam Smalls	29/- to 30/-
Ordinary ,,	25/- to 28/-
Washed Nuts	30/- to 35/-
No. 3 Rhondda Large	39/- to 40/-
,, ,, Smalls	30/- to 32/6
No. 2 ,, Large	32/6 to 34/-
,, ,, Through	29/- to 31/-
,, ,, Smalls	25/- to 27/-
Coke (export)	70/- to 80/-
Patent Fuel	40/- to 45/-
Pitwood (ex ship)	28/6 to 29/6
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	45/- to 47/6
Seconds	42/6 to 45/-
Red Vein	32/6 to 35/-
Machine-made Cobbles	50/- to 52/6
Nuts	50/- to 52,6
Beans	45/- to 47/6
Peas	25/- to 26/-
Breaker Duff	12/- to 13/-
Rubbly Culm	17/- to 17/6
Steam Coals:	
Large	27/6 to 30/-
Seconds	25/- to 27/-
Smalls	19/- to 21/-
Cargo Through	22/- to 24/-

(1) Delivered. (2) Net Makers' works. (3) At furnaces. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—F.O.B. Glasgow.

(8) Except where otherwise indicated coals are per ton at pit for inland and f.o.b. for export and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b.

* Quotations extremely high and nominal.

French Engineering Notes.

(From our Correspondent in Paris.)

Production Costs.

ALTHOUGH there is a firm belief here that the occupation of the Ruhr was inevitable and that the action taken by the French will be fully justified in time, it has, nevertheless, created a state of things which is very serious for the industrial situation. Having to buy so much raw material abroad to make up for the deficit from Germany, the cost of that material has increased and the value of the franc has declined, and as imported foodstuffs have to be paid for with a depreciated currency, their high cost has been followed by the levelling up of prices of home produce. There is consequently an increase in the cost of living which is telling seriously upon the cost of production. A few months ago operatives consented to wages reductions because living had become cheaper, but now that everything has gone up in price, the men are beginning to clamour for a return to the higher wages, which employers refuse to pay, in the belief that the present inflation of prices is due to temporary causes. There are strikes in the weaving industry in the north, and the men have left one of the big engineering works because they cannot get a return to the recent scale of wages. The situation therefore is generally unsettled, and will remain so until the outlook becomes more definite. While there is a prospect of the engineering trades being burdened with a higher wages bill, much more has to be paid for fuel, and if there have been no further advances in iron and steel during the week, except for certain kinds, makers cannot always get material, and orders have often to be refused because there is no reasonable hope of executing them. As work is fairly plentiful and production costs are increasing, makers find themselves in the position that if the value of the franc should improve to any appreciable extent their prices will be higher than those in certain other countries, with the result that there may be a possibility of British and other firms doing business in this market.

Petrol Locomotives.

The results already obtained with petrol locomotives on local lines have encouraged the State railways to employ them for such intermittent services as shunting. At the Gare St. Lazare tests have been carried out with a 100 horse-power petrol locomotive supplied by the Etablissements Baudet Donon, and it is claimed that the work done is quite as satisfactory as with steam locomotives. The economy is so great that a dozen similar locomotives have been ordered. In view of this success, it is believed that the petrol engine will soon be making considerable headway in rail traction, for most of the big petrol motor firms are building locomotives, and one of them has plans in hand for a 400 horse-power locomotive for passenger service. It is now recognised that for the arduous conditions of rail work, the petrol locomotive must have great flexibility, and in the shunting engines a special type of gear box is provided, giving no fewer than twelve changes of speed. Apparently, the petrol locomotive will require a distinct type of transmission.

Desert Traction.

The successful crossing of the Sahara by Citroën cars fitted with Kégresse rubber tracks is already suggesting practical uses for these vehicles in the desert regions to the south of Algeria and Tunis. The whole of the country along the western border of Tripoli is in a state of insecurity, owing to the raids of brigands, who drive flocks of sheep from the Tunis territory into Tripoli. The Resident-General of Tunis is hoping to put an end to this state of things by making a journey to the extreme south of the Tripoli frontier, and he has started this week with three Citroën cars, carrying half a dozen passengers, the caravan being accompanied by a military camel corps and aeroplanes with wireless. The length of the journey will be about 1250 miles. While being intended to impress hostile tribes with the power of the motor car as a means of penetration, it will also trace the first stage of a route to Lake Tchad, which, it is hoped, will be opened up eventually with motor vehicles. When the Resident-General has completed his voyage of inspection, the three cars will be handed over to various military posts in the desert.

Summer Time.

On account of the refusal of the agricultural representatives in Parliament to permit of a discussion on the advisability of adopting summer time, many thousands of Belgians who daily cross the frontier to work in French factories find themselves held up through the Belgian and French railway services no longer coinciding. In many industrial centres employers are adopting summer time to the satisfaction of the men, and in the Lyons district especially the system is rapidly extending. All the Chambers of Commerce and industrial bodies are agitating strongly for the change, while the electrical distribution companies are again insisting upon the great economies to be effected by advancing the hour during the summer months. So general is the movement, that the Government intends to open a debate on the subject on the reassembling of the Chamber of Deputies.

Horse-power.

The abbreviation HP is so generally employed in France that it seems almost hopeless to attempt to eradicate what has become a confirmed habit. Nevertheless, the Gas and Petrol Makers' Association has waged war upon the English power unit, and has ordained that it shall be replaced by the abbreviation CV, for *cheval vapeur*, which, moreover, has been officially adopted for aeroplane engines. It is argued that it is not only illogical to employ a foreign power unit, but also erroneous and misleading, since the HP, representing approximately 76 metre-kilogrammes per second, is about 1 metre-kilogramme per second more than the CV. Notwithstanding the efforts to secure a greater precision in nomenclature, it will probably be a long time before the HP is superseded.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

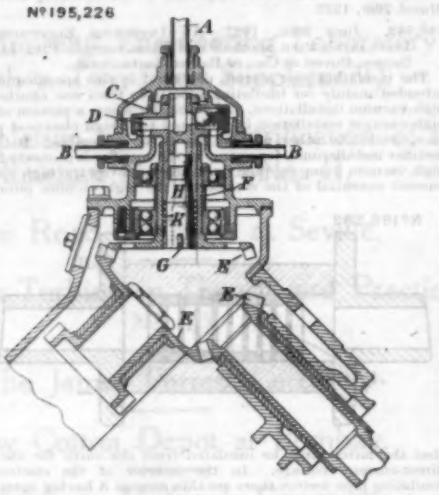
The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

195,226. February 10th, 1922.—STARTING AIR VALVES, D. Napier and Son, Limited, and G. S. Wilkinson, 211, Acton Vale, London, W. 3.

This valve is of the rotary disc type and receives its supply of compressed air through the pipe A. B B are pipes leading to the cylinders. The valve C has a radial passage and port D, which registers, in turn, with the ports of the pipes B B and thus distributes air to the cylinders. The valve is driven off the crank

N° 195,226



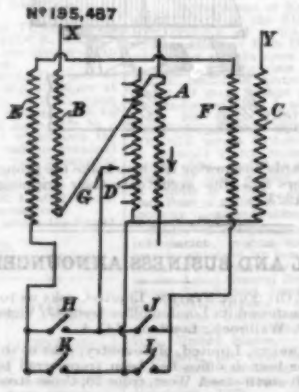
shaft through the bevel wheels E E E. The stalk of the valve is free inside the sleeve F of the last bevel wheel, but is driven through the feathers G and the friction cone H. A spring K tends to lift the valve off its seating, but when air is admitted the force of the spring is overcome. The coupling H permits of the valve being adjusted.—*March 29th*, 1923.

TRANSFORMERS AND CONVERTERS.

195,487. January 30th, 1922.—A VOLTAGE REGULATOR FOR ELECTRIC ALTERNATING-CURRENT CIRCUITS, Johnson and Phillips, Limited, of Victoria Works, Charlton, and Harold Morgan Lacey, of 18, Burland-road, Clapham.

The special method of regulating the transformer described in this specification will be understood from the diagram. The supply voltage is applied across a primary winding A, which forms also a secondary winding. The secondary windings B and C are arranged on the other two limbs of the transformer in series with the winding A. Winding B acts in opposition to winding A and winding C acts with A. The outgoing lines are connected to the terminals X and Y. Under normal conditions the equal and opposite effects due to the windings B and C cancel and the voltage supplied to the terminals X and Y is that due to the auto-transformer winding A. The windings A, B and C are called the main windings, the winding A being the primary winding and the windings A, B and C the secondary windings. In addition to the windings A, B, C, short-circuited auxiliary windings D, E and F are wound on the corresponding limbs. The winding D is provided with tappings adapted to be engaged by an arm G. Switches H, J, K and L are arranged as shown in the circuit of the auxiliary windings. In order to reduce the voltage in the

N° 195,487

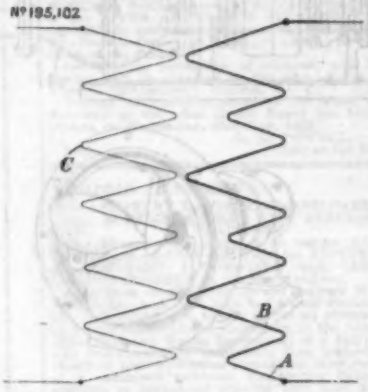


load circuit, switches H and L are closed and the arm G engages with a suitable tapping on the winding D. A closed circuit is thus formed, consisting of the windings E and F and a portion of the winding D. With no current flowing in this circuit the voltages in E and F are balanced; hence the voltage in D sends a current round this circuit. This current causes a flux which acts with the main flux in winding B and opposes the main flux in winding C; thus the voltages in windings B and C are correspondingly increased and decreased respectively. Each of these effects tends to decrease the voltage across the points X and Y. The reduction of voltage is regulated by the position of the arm G and is approximately proportional to the distance of the arm from the bottom of winding D. To increase the voltage applied between the terminals X and Y switches J and K are closed, H and L being open. A closed circuit is thus formed consisting of the windings E and F and a portion of the winding D. The current in this circuit causes a flux which acts with the main flux in winding C and opposes the main flux in winding B. Thus the voltages in windings C and B are correspondingly increased and decreased respectively. Each of these effects tends to increase the voltage across the points X and Y. The number of turns in the auxiliary windings D E F is immaterial, provided that the turns in these windings bear the same proportion to the turns in their respective main windings. The auxiliary windings must have sufficient current carrying capacity to provide the same number of ampere turns as their respective main or secondary windings.—*April 5th*, 1923.

195,102. January 10th, 1918.—IMPROVEMENTS IN HIGH-FREQUENCY TRANSFORMERS, Archibald Montague Low, of the Royal Flying Corps' Experimental Works, Feltham, Middlesex.

One winding of the high-frequency transformer described in thi sspecification—the secondary winding, for example—has two sets of turns A and B arranged excentrically to one another so that the respective turns approach one another more nearly at one part than at any other part, and the turns—constituting one set, such as A—are of smaller diameter than the turns of the other

N° 195,102



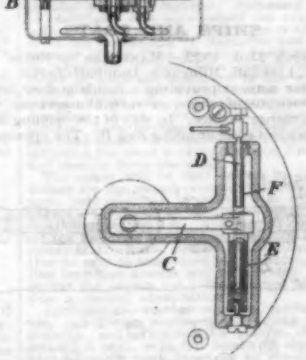
set B. The primary coil is shown at C. The transformer produces a small high-tension current and a large low-tension current and one lags behind the other. It has been found, the inventor states, that such a transformer is particularly suitable for the wireless control of torpedoes, aeroplanes, or other objects which it may be desired to control from a distance.—*March 5th*, 1923.

MEASURING AND TESTING INSTRUMENTS.

195,229. February 13th, 1922.—PRESSURE GAUGES, C. J. Stewart, W. W. Stainer and E. A. Griffiths, Air Ministry, Alexandra House, Kingsway, London.

This invention relates to means for making a tight joint where the indicating spindle of a differential pressure gauge emerges from the casing. The instrument comprises a casing A, inside which there is a flexible chamber B. Pressure connections are

N° 195,229



made with the interior of the chamber and the casing. Movements of the chamber diaphragm are indicated by the lever C and spindle D. The lever is fixed on a sleeve E that is keyed to one end of a tube F. The indicating spindle is attached inside the tube at the same end. The tube F is flexible torsionally and thus permits the spindle to turn while maintaining a pressure-tight joint.—*March 29th*, 1923.

TRANSMISSION OF POWER.

195,494. February 6th, 1922.—IMPROVEMENTS IN OR RELATING TO THE MANUFACTURE OF ELECTRIC CABLES, Callenders Cable and Construction Company, Limited, and Philip Vassar Hunter, of Hamilton House, Victoria Embankment, E.C. 4.

This specification describes a method of impregnating the insulation of an electric cable in which the core or conductor is cooled so that the cooling of the impregnating material takes place partly from inside. In the example illustrated the con-

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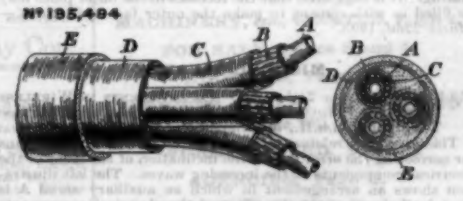

ducting core is formed partly by a tube A, preferably of copper, and partly by stranded conductors B laid up round the tube A in close contact with it. The insulation C surrounding each conducting core is preferably of paper or some insulating material which, after being wound round the core in some well-known

way, is impregnated in the manner usual in such cables. The outer insulation D and covering E may be of any known form. The cooling medium is passed through tube A and the core of the cable is cooled at an appropriate stage in the impregnating process, so that the cooling takes place partly from the inside.—*April 5th*, 1923.

PUMPING AND BLOWING MACHINERY.

195,166. January 10th, 1922.—CENTRIFUGAL PUMPS, S. H. Adams, White House, Sandsend, Yorks.

The inventor claims that in this pump, unlike others of a somewhat similar form, the water passes through from suction to outlet as a practically solid jet. The impeller is virtually a

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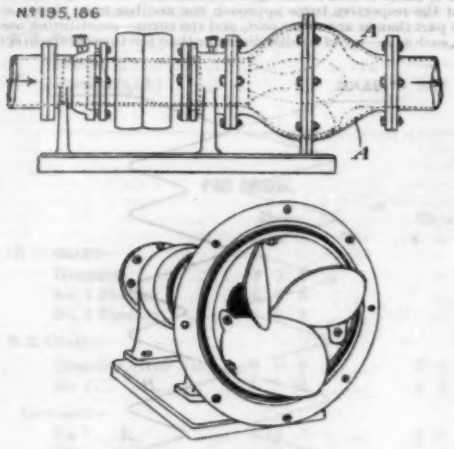


screw propeller, through the hollow axle of which the water enters. Belt pulleys are provided on the hollow axle for driving the impeller and stuffing-boxes arranged to make water-tight joints. Guide vanes A A near the outlet reduce the swirling of the outgoing water.—*March 29th*, 1923.

LIGHTING AND HEATING.

177,811. April 3rd, 1922.—IMPROVEMENTS IN ELECTRIC GAS LAMPS WITH GLOW DISCHARGE, *Patent-Treuhand-Gesellschaft fur Elektrische Gluhlampen mit beschrankter Haftung, Ehrenbergstrasse*, 11/14, *Berlin, O*, 17.

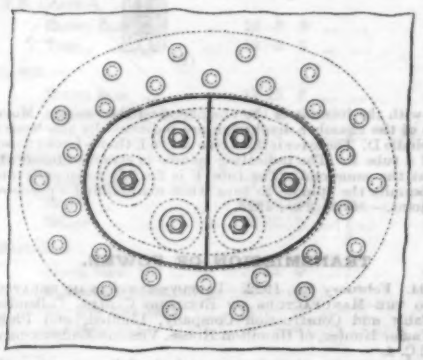
This invention relates to an electric gas lamp with glow discharge, filled with a mixture of neon and helium. It has been ascertained as a result of experimental research that with further additions of helium to the neon-helium mixture obtained by the frictionation of air (*i.e.*, 20 to 25 per cent. helium to 80 to 75 per cent. neon) a considerable increase in economy takes place and at a certain percentage of helium the lighting efficiency reaches a maximum. When the gas pressure is about 10 mm. mercury column the maximum of economy is obtained with a mixture of 25 per cent. neon and 75 per cent. helium. Accordingly the invention consists in using a mixture of neon and helium approximately in the proportion affording the greatest ratio of light emitted to power consumed. It is thus possible to obtain about twice the light efficiency obtainable with pure neon.—*March 22nd*, 1923.

SHIPS AND BOATS.

194,943. March 23rd, 1922.—MANHOLES IN SHIPS' BOTTOMS, A. Cross, Llandaff, Milngavie, Dumbartonshire.

The inventor aims at providing a manhole door for access to the double bottoms of ships, or such-like services, that shall have a flush exterior surface. In way of the opening in the main plating A there is a compensating ring B. The opening is closed

N°194,943



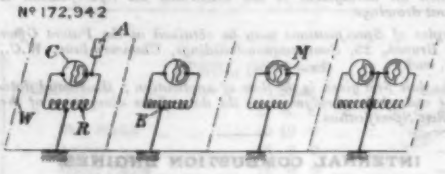
by the cover C, which is held in place by an outer plate D and bolts E E. The outer plate is preferably made in halves and is recessed so that the bolt heads do not extend beyond the skin plating. It is suggested that the recesses in the outer plate may be filled in with cement to make the outer face quite flush.—*March 22nd*, 1923.

MISCELLANEOUS.

172,942. November 24th, 1921.—IMPROVEMENTS IN WIRELESS DIRECTION FINDING APPARATUS, Gesellschaft für Drahtlose Telegraphie m.b.H., of Tempelhofer ufer, Berlin.

This invention relates to a frame aerial provided with means for correcting the error due to the inclination of the front of the electrical components of the incoming waves. The left illustration shows an arrangement in which an auxiliary aerial A is used for balancing out the effect of the electrical components of the waves. The condenser C consists of a set of movable plates P and a set of fixed plates. A metal case surrounds the condenser and is structurally and electrically connected with the fixed plates. A frame aerial R is connected to both sets of plates. The movable plates have the smaller capacity to earth, and this is corrected by the auxiliary aerial A. The receiver is coupled as usual to the inductance in the bottom of the frame. In the next diagram an arrangement is illustrated in which the earth connection E is placed unsymmetrically. The earth connection on the frame aerial is shifted so that the smaller earth capacity of the movable plates is corrected by more turns of the frame aerial. In the third arrangement the condenser is sur-

N°172,942

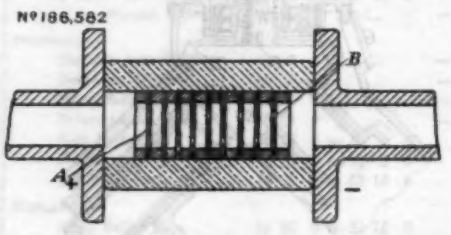


rounded by a metal case M, which, in contradistinction to the preceding arrangements, is insulated from both sets of plates. The case is connected to the earthed point of the winding of the frame to obtain balance. The fourth diagram shows an arrangement of two condensers, the moving plates being connected together and to the earthed point of the frame aerial. The arrangements shown have frame aerials which are inclined in the direction of the wave front. The dotted line W represents the front of the electrical component of the incoming wave.—*March 26th*, 1923.

186,582. June 30th, 1922.—AN IMPROVED ELECTRICALLY INSULATING PIPE SECTION FOR HIGH-VACUUM PIPE LINES, Brown, Boveri et Cie., of Baden, Switzerland.

The insulating pipe section described in this specification is intended mainly for insulating pipe lines from one another in high-vacuum installations, and especially where a portion of the high-vacuum installation is subjected to a high electrical pressure, while the other portion has to be accessible. In large rectifier installations, for example, the rectifier is connected to a high-vacuum pump by pipe lines which convey the high direct-current potential of the rectifier to the high-vacuum pump so

N°186,582

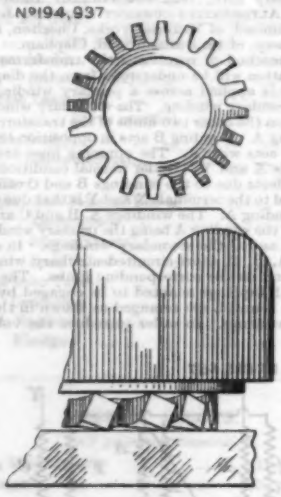


that the latter must be insulated from the earth for the full direct-current voltage. In the interior of the electrically insulating pipe section there are thin screens A having apertures B which are staggered relatively to one another. When an electron moves in a direction parallel to the axis of the pipe through an aperture in a screen it does not pass directly into the aperture of the following screen, but impinges with great velocity against the wall of the next screen, whereby it loses a large part of its kinetic energy.—*March 29th*, 1923.

194,937. March 15th, 1922.—A NUT LOCK, R. T. Hosking, 623, Sheridan-avenue, Saginaw, Michigan.

The form of this nut lock is fairly obvious in the drawing. It is made by slightly twisting the prong-like projections round the edge of the washer. The inventor claims that any movement

N°194,937



of the nut towards unscrewing tends to make the prongs roll over on their corners and thus accentuate their gripping action.—*March 22nd*, 1923.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

THE CLYDE OIL FUEL SYSTEM, Limited, asks us to announce that it has transferred its London office from 47, Victoria-street, S.W. 1, to 37, Walbrook, London, E.C. 4.

ALFRED HERBERT, Limited, of Coventry, asks us to state that its Manchester branch office has been transferred to Wrendal House, 2, Whitworth-street West, from 30, Cross-street.

MR. ARTHUR MARES, F.I.C., A.R.C.Sc., A.M.I. Mech. E., A.R.S.M., who has been for the past seven years metallurgist and head of the testing department of Harland and Wolff, Limited, Belfast, informs us that he has resigned that position for family health reasons, and that he has now been appointed metallurgical adviser to A. Harper Sons and Bean, Limited, Dudley, Tipton, and Smethwick.

CONTRACTS.

THE D.P. BATTERY COMPANY, Limited, of Bakewell, Derbyshire, has recently completed at Polesden Lacey, near Dorking, the residence of the Hon. Mrs. Ronald Greville, the installation of a battery of nearly 1000 ampère-hours' capacity for lighting purposes. The work was done to the order of Mr. E. Wingfield Bowles, the consulting engineer.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

CHEMICAL ENGINEERING GROUP.—The Engineers' Club, 30, Coventry-street, W. 1. Annual general meeting and dinner. 6.30 p.m.

INSTITUTE OF METALS.—University College, Singleton Park, Swansea. Annual general meeting. 7.15 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, S.W. 1. Twenty-ninth James Forrest Lecture entitled "The Interdependence of Abstract Science and Engineering," by Sir Richard T. Glazebrook. 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. Lecturette, "A.C. Neutral Point Earthing," by Mr. S. A. Stigant. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—Albemarle-street, Piccadilly, W. 1. Discourse, "The Origins of the Conception of Isotopes," by Professor Frederick Soddy. 9 p.m.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Kiosk Café, North-street, Keighley. Annual general meeting. 7.15 p.m.

SATURDAY, MAY 5TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—London graduates' visit to the headquarters of the London Fire Brigade, Southwark Bridge-road, S.E. 1. 3 p.m.

INSTITUTION OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—College of Technology, Manchester. Annual business meeting. 4 p.m.

LONDON ASSOCIATION OF FOREMEN ENGINEERS.—Cannon-street Hotel, E.C. 4. Seventieth anniversary festival. 6.30 p.m.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Visit to the new power plant at Grove Mills, Ingrow, Keighley. 2 p.m.

MONDAY, MAY 7TH.

SOCIETY OF ENGINEERS.—The Geological Society, Burlington House, Piccadilly, W. 1. "Pneumatic Handling of Petrol and other Inflammable Liquids," by Pierre Mauclère. 5.30 p.m.

INSTITUTE OF TRANSPORT.—Institution of Electrical Engineers, Savoy-place, W.C.2. Paper, "The Investigation of the Financial Prospects of Railway Electrification," by Sir Philip Dawson. 5.30 p.m.

TUESDAY, MAY 8TH.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Royal Society of Arts, John-street, Adelphi, W.C. 2. Paper, "Heavy-grade Egyptian Crude Petroleum," by Mr. W. A. Guthrie. 5.30 p.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.—Queen's Chambers, 5, John Dalton-street, Manchester. Paper, "Notes on Three Ignitions of Firedamp Caused by Shot Firing," by Mr. F. N. Siddall. 3 p.m.

WEDNESDAY, MAY 9TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Institution of Mechanical Engineers, Storey's-gate, S.W. 1. Paper, "The Endurance of Ball Bearings, with Particular Reference to Automobile Practice," by Mr. A. Macaulay. 7.30 p.m.

INSTITUTE OF PHYSICS.—Institution of Electrical Engineers, Savoy-place, W.C. 2. "The Application of Physics to the Ceramic Industries," by Dr. J. W. Mellor. 5.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS: LANCASHIRE AND CHESHIRE BRANCH.—Whitworth Engineering Laboratories, Victoria University, Coupland-street, Manchester. Paper, "Education of a Structural Engineer," by Mr. H. W. Clapham. 7.15 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, W.C. 2. "Surface Combustion, with Special Reference to Recent Developments in Radiophragm Heating," by Professor W. A. Bone. 8 p.m.

THURSDAY, MAY 10TH.

ROYAL INSTITUTION OF GREAT BRITAIN.—Albemarle-street, Piccadilly, W. 1. "Modern Electric Lamps: III., Glowing Gases (Neon Lamps)," by Professor J. T. MacGregor Harris. 3 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, W.C. 2. Presentation of the Faraday Medal to the Hon. Sir Charles A. Parsons. Fourteenth Kelvin Lecture, "Problems in Telephony Solved and Unsolved," by Dr. J. A. Fleming. 6 p.m.

THURSDAY AND FRIDAY, MAY 10TH AND 11TH.

IRON AND STEEL INSTITUTE.—Institution of Civil Engineers, Great George-street, S.W. 1. Annual meeting. For programme, see page 401. 10 a.m. each day.

FRIDAY, MAY 11TH.

INSTITUTION OF AERONAUTICAL ENGINEERS.—The Engineers' Club, Coventry-street, W. 1. Lecture, "Low-power Flying," by Major M. E. A. Wright. 6.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION.—Royal Society of Arts, John-street, Adelphi, W.C. 2. Paper, "Some Notes on 'Ciment Fondu'—a Cement of High Initial Resistance—with Results of Chemical Analyses by Harley F. Knight, F.I.C.," by Mr. H. J. Davey. 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. Durham Bursar's Lecture, "The Theory of Resistance to the Flow of Gases and Fluids in Pipes," by Mr. W. F. C. Cooper. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—Albemarle-street, Piccadilly, W. 1. Discourse, "Gaseous Combustion at High Pressures," by Dr. W. A. Bone. 9 p.m.

SATURDAY, MAY 12TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—South Wales District meeting. Joint visit with members and students of the Institution of Civil Engineers to the Merthyr Reservoirs. Paper by Mr. F. Harvey, acting engineer of the Taf Fechan Water Supply Board, entitled "The Waterworks Undertaking of the Taf Fechan Supply Board," will be considered and discussed. Train leaves Merthyr Station for Pontsticill 12.10 p.m.

TUESDAY, MAY 15TH.

INSTITUTE OF TRANSPORT.—Institution of Electrical Engineers, Savoy-place, W.C. 2. Graduates' and students' lecture, "The Design and Maintenance of Commercial Motor Vehicles," by Mr. G. J. Shave. 5.30 p.m.